Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1082

Washington, D. C. ▼ October 19, 1922

THE PRODUCTION OF TULIP BULBS.

By David Griffiths, *Horticulturist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

CONTENTS.

	Page.		Page.
The tulip bulb	2	When tulips are ripe	15
Preparation of the soil for tulips	3	Digging tulips	15
Laying out lands for planting	3	Droppers	17
Planting tulips	4	The bulb house	18
Treatment of the beds after planting	10	Packing tulips for shipment	25
Age of flowering bulbs	11	Preparation of stocks for planting	27
Blindness	12	Implements of tulip-bulb production	28
Relation of size of bulb to size of flower	12	The duty of labor	30
Early maturity affecting the blossoming season	13	Soils	33
Sale of flowers	13	Enemies of tulips	36
Removing the flowers	14	Why some varieties are cheaper than others	38
		Performance records	39

GOOD TULIPS can be grown in America at a profit. They have already been produced in sufficient quantities and for a period long enough to command respect.

The tulips already produced experimentally are as good as the best. They bed, they force, they produce, and they reproduce normally under American conditions. This, coupled with the prospect of a profit in the growing, should beget a new industry in America. This industry, however, it is believed, must develop slowly, for experience is necessary and is as slowly acquired in this as in any other horticultural venture. It is also probable that the industry will not be more than supplementary to the existing sources of supply for many years, for it is scarcely probable that it can do more than meet the increment of tulip-bulb consumption which is certain when our economic conditions and transportation facilities again become normal.

There is, however, no limit to the quantity of bulbs which it is possible to produce in the United States. We have climates that are unexcelled for the production of these stocks. We have regions with

an abundant moisture supply from October to June, and we have dry summers. We have fertile sands, inexhaustible loams, and deep friable silts, upon all of which tulips can be grown.

With the start which has already been made by the Department of Agriculture on Puget Sound, by three or four companies in southern Michigan, by an association in the Willamette Valley, by a company in northwestern California, another in the Norfolk (Va.) region, and a score more in a smaller way in many scattered localities, the prospective grower should have no difficulty in obtaining the information required to enable him to avoid the pitfalls and to take advantage of the essential elements of success. This bulletin furnishes some of the necessary information. It is based upon investigations made on Puget Sound at Bellingham, Wash., in two locations, the first on the shore of Bellingham Bay and the second 3 miles inland.

THE TULIP BULB.

The whole tulip plant at maturity is condensed into a gigantic bud, called a bulb (see Pl. I), not very different from an onion. In the tulip, however, there is a single, continuous, usually brown protective covering. On the front of the mature bulb is a groove marking the position of the flower stem of the previous season (Pl. I, Figs. 2 and 3), the base of which usually remains attached to the base of the bulb. A full-grown bulb which has not flowered has a long stout neck and no flower-stem groove. (Compare clumps in Pl. I, Fig. 4.) The long neck is the petiole or stem of a strong leaf (Pl. II, Figs. 2 and 3) produced the year before flowering. (Compare the two clumps in Pl. I, Fig. 4, with Pl. II, Figs. 2 and 3.)

The bulb is made up of concentric layers attached to a basal plate (stem), between which at certain points are found buds, some or all of which, when the bulb is planted, develop into new bulbs, which may vary in size from 3 to 14, or in rare cases 20 centimeters in circumference. Usually one, often two, and sometimes three bulbs of this cluster will flower the next year, but it is seldom that more than one will give a first-class bulb of merchantable quality. (See clumps in Pls. III to V.)

The bulb of the tulip, unlike that of the narcissus, is always the product of the current season's growth and is not more than one year of age. One or more bulbs (Pl. III) are formed each season from each bulb planted, the size, quality, and number of such increase being directly dependent upon the size, vigor, and quality of the bulb planted; the soil, climatic factors, fertility, tilth, freedom from weeds; the general care and condition of the planting; and the character and adaptability of the variety.

The bulb grower is dependent for his profit on the character of the large bulb of this cluster, and for the continuation of his business

upon the nature and abundance of the smaller increase, commonly referred to as "the propagation." His planting is composed essentially of the bulbs below the largest bulb in the cluster, together with the small bulbs of the previous year's planting which have not grown to merchantable size during the current season.

PREPARATION OF THE SOIL FOR TULIPS.

Tillage for tulips should be thorough and deep. Upon the Whatcom silt loams of the Bellingham Bay region, where the work has been carried on, the average depth of the soil is not more than 12 to 16 inches. Thus far no subsoiling has been done, but the land has been prepared as deeply as possible with an ordinary 14-inch, steel-beam walking plow, 10 inches being probably close to the depth of the best preparation. Greater depth would undoubtedly be desirable, but good crops can be grown with this character of preparation on land where the drainage is cared for either by contourage, natural slope, or porosity of subsoil.

The soil is put in as fine a tilth as possible by the use of harrow, disk, float, and pulverizer packer. An almost indispensable tool is the rolling-disk clod crusher and packer, which has been used very largely on both silt and sandy soils, on the former mainly to pulverize and on the latter to pack the soil so that the edges of the beds will hold when marked out.

The proper use of tillage and soil-packing machinery exhibits in the highest degree the skill and efficiency of the grower in putting the bulb fields in just the right state of fineness and compactness, not only for the best crop results but also for the best handling in the planting of the crop.

LAYING OUT LANDS FOR PLANTING.

It is needless to say that, as in all farming operations, bulb lands should be rectangular in outline wherever it is possible. If lands are heavy and therefore to be bedded up, they have been roughly outlined by the tillage implements and are ready to have the ends of the beds marked. It is the practice to stretch a line on each side of the plat, the length of which is governed by the size of the field. The experimental plats were approximately 400 feet long. Along these taut lines a man proceeds with a 12 or 15 foot marker, on which are designated 36-inch and 12-inch spaces, alternating. With this he marks out the corners of the beds and drives stakes in each corner. If the sides of the plat are parallel, or, in other words, if the plat is of uniform width and the first stakes on each side of the plat are set directly opposite each other, the beds are rectangular, and no difficulty will be experienced in the future work provided the measurements are accurate. It is well to exercise much care in setting the

first stakes, even to laying out the first corners with a square, for future operations are facilitated by accuracy in these initial preparations.

When the corners of the beds have been marked by stakes, the beds are marked off. This is done by first stretching a taut line on each side of the bed, guided by the previously driven stakes. Two men usually work at this job and open up a number of beds in advance of planting. Each man handles one end of the two lines. When they have been fastened, one man marks one and the other the other side of the bed, being guided by the taut line (see right of Pl. VI, Fig. 2). They drive the spade into the ground vertically 2 to 3 inches and pull the dirt toward the center of the bed with a sort of scraping motion. When each has marked his side, they are at opposite sides of the plat ready to take up the lines and transfer them to the next bed and continue the work in this way to the end of the plat.

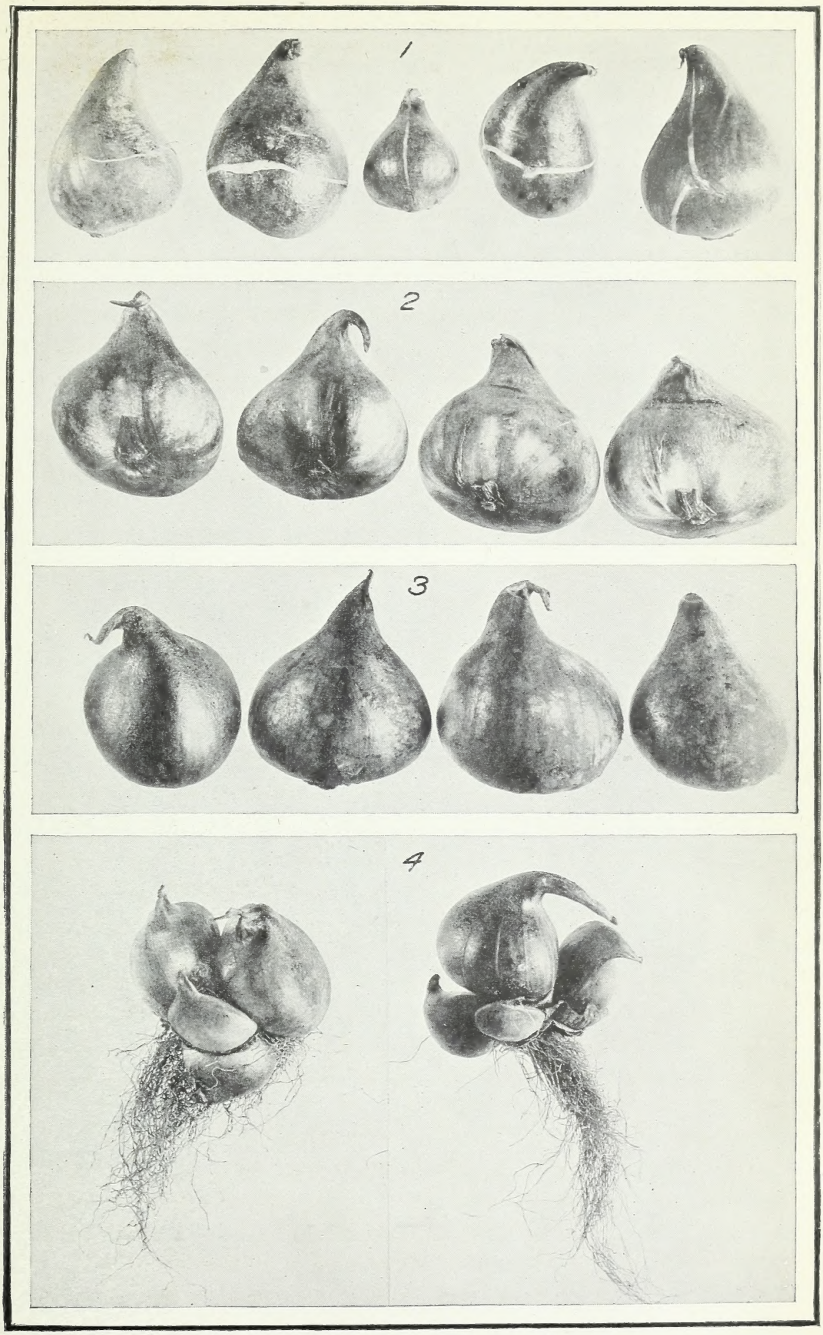
The width of the plat is the length of the bulb bed. The length of the bed is arranged purely as a matter of convenience in handling the bulbs in digging and planting.

PLANTING TULIPS.

The process of setting the bulbs in the ground is not essentially different for a great variety of bulbs. After the beds are marked off preparation for planting begins. All the soil to a depth of about 4 inches is thrown out of the first bed. The bottom is raked to a uniform level and fined with a garden rake. A roller marker is next run over the bed thus prepared. (Pl. VI, Fig. 1.) As soon as a space of 4 or 5 feet in the bed has been set with bulbs, the man with the shovel begins to open up the second bed by taking out the soil to a depth of about 4 inches, as before, and using it to cover the bulbs in the first bed; in other words, the soil taken out in opening a bed is used to cover the bulbs in the previous bed all the way across the plat. With experienced bulb men the marker is unnecessary, for they are able to set the bulbs in the required geometrical design without guidance.

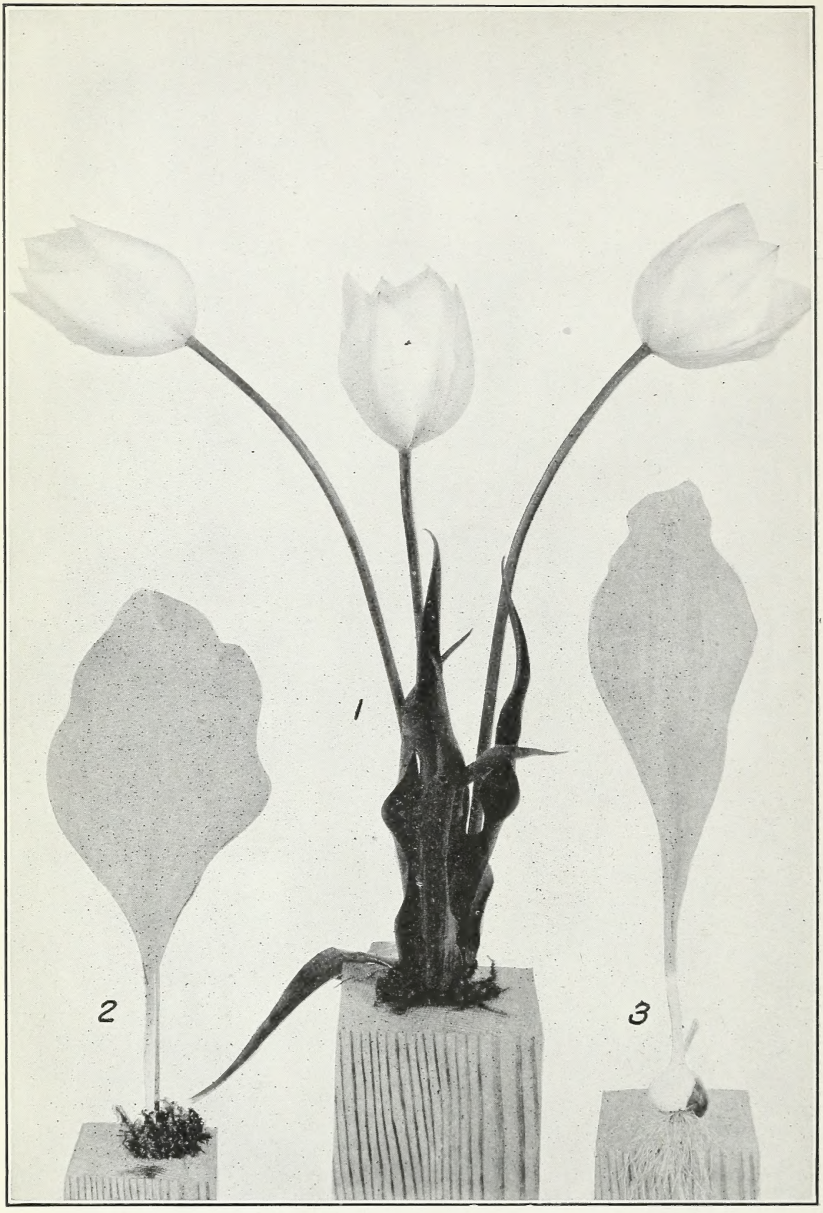
HOW THE BULBS ARE SET.

The method of setting the bulbs varies with the different sizes. With tulip bulbs above 9 centimeters in circumference or with those sizes which are set upright, it is considered advantageous to strew them along the bed from the containers in which they are brought to the field. One man on each side of the bed on his knees sets the bulbs, usually 9 or 11 to a 3-foot row. When planting small sizes, indeed when planting all sizes below about 8 centimeters or those not set upright, it is advantageous to have small boxes a foot square and about 3 inches deep to hold the bulbs, which are



McKINLEY, FARNCOMBE SANDERS, AND CLARA BUTT TULIP BULBS.

FIG. 1.—Flowering bulbs of McKinley, showing the coats just starting to split from overexposure to light and air. FIG. 2.—Flowering bulbs of Farncombe Sanders, showing front of the tulip bulb (side next the stem). FIG. 3.—Same as Figure 2, but showing back of the bulb. FIG. 4.—Bulbs of Darwin tulip Clara Butt, showing bulb which flowered this year (left) and one which did not (right), the former planted 14 and the latter 21 to the row.



SINGLE EARLY TULIPS.

FIG. 1.—White Swan, showing the aboveground parts of three flowering plants. FIG. 2.—Keizerkroon, showing the aboveground parts of a plant whose bulb is too small to flower this year but which will flower the next season. Note the single very large leaf. FIG. 3.—Cardinal's Hat, a complete plant of a nonflowering-sized bulb which will grow to flowering size this year. Note as in Figure 2 that the single leaf is comparatively large.

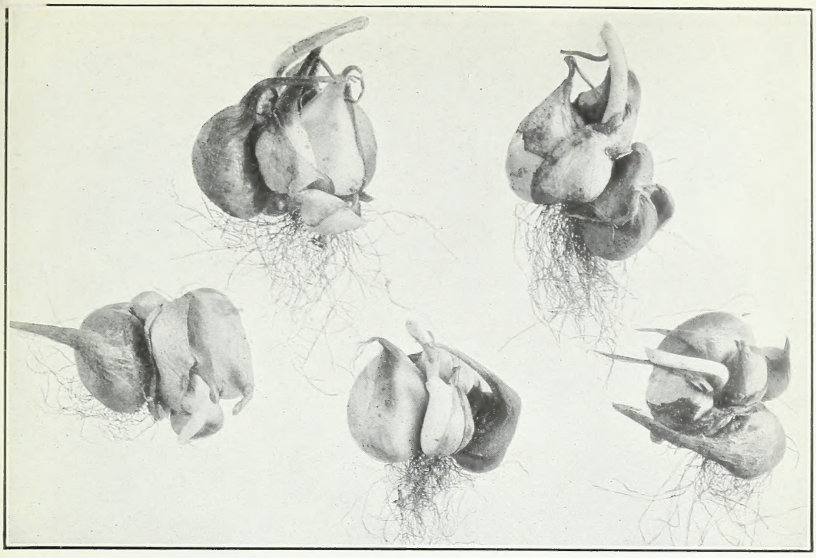


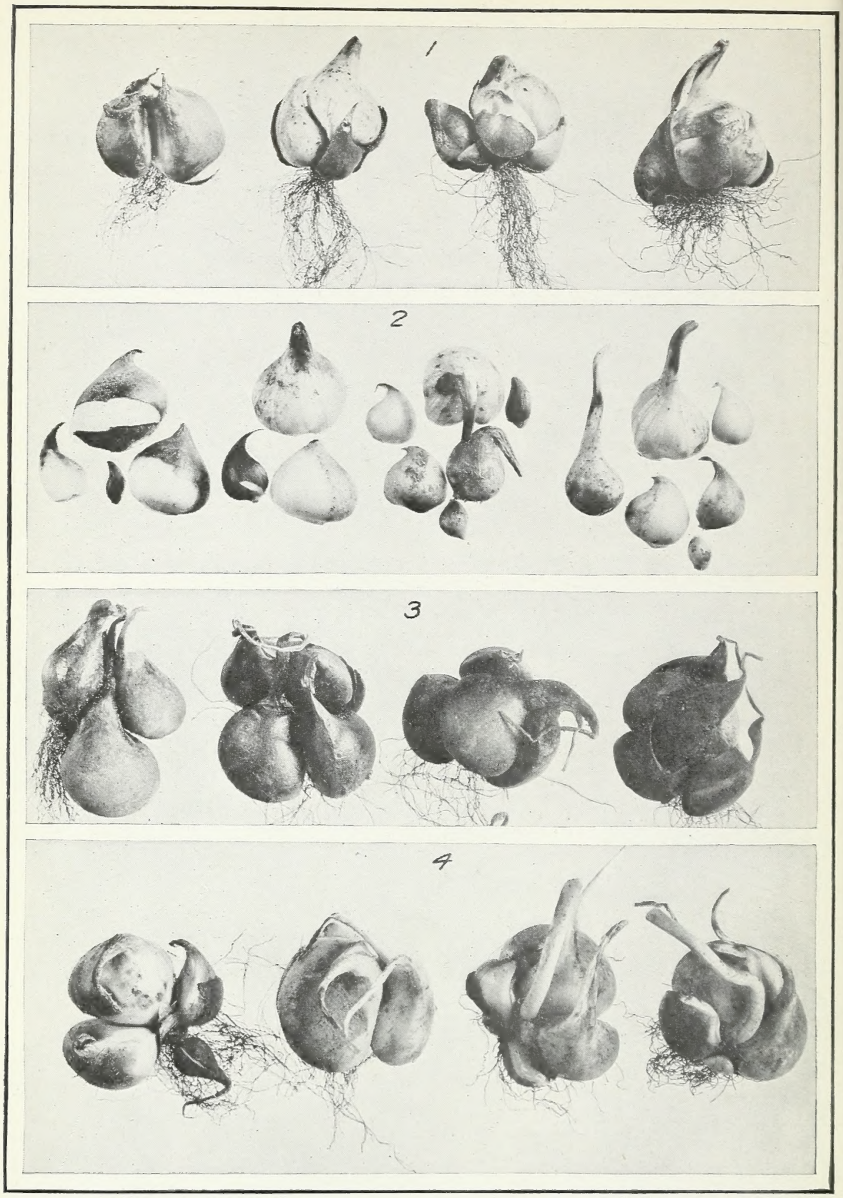
FIG. 1.—FIVE CLUMPS OF AXIMENSIS TULIP BULBS GROWN FROM 8-CENTIMETER BULBS.

Note that all have flowered and that there is a preponderance of long necks even in the increase. The bulbs have grown to 10 centimeters and have produced two 9, two 8, seven 6, eight 5, five 4, and three 3 centimeter bulbs in the increase. Besides the mother bulbs, at least four more will blossom next year.

FIG. 2.—FIVE CLUMPS OF MACROSPHILA TULIP BULBS.

These were dug at the end of two years from 7-centimeter bulbs set 21 to the row. There are now five 12, seven 8, four 7, seven 6, five 5, and four 4 centimeter bulbs. Note the large masses of roots and preponderance of old coats.

SINGLE LATE TULIP BULBS



ARTUS AND ROSALIND TULIP BULBS.

FIG. 1.—Four clumps of the single early tulip Artus. The bulbs planted were 8 to 9 centimeters and set 14 to the row. FIG. 2.—The same as Figure 1, with bulbs cleaned and separated. Only the one on the left blossomed, but all have reached flowering size and each clump has produced two bulbs which will flower next year. FIG. 3.—Four clumps of the single late tulip Rosalind from 8 to 9 centimeter bulbs set 14 to the row. None have flowered. Note that more than one bulb in a clump has a long neck, indicating that each bulb planted produced more than one strong basal leaf which insures added vigor. This characteristic is seldom seen in the single earlies or Darwins. FIG. 4.—Four clumps of the same variety as Figure 3 and planted the same, but these have flowered. Note the long necks on two of the increase in each clump.

THE SULTAN AND CLARA BUTT DARWIN TULIP BULBS.

FIG. 1.—Three bulbs of the Sultan in clumps as dug. These were planted as 7-centimeter bulbs; all have flowered and reached mature size. FIG. 2.—The same as Figure 1, with the bulbs cleaned. Note the flower stems on each bulb planted; in each group are two bulbs which will flower next year. FIG. 3.—Five clumps of Clara Butt as dug, with some of the old hulls pulled off. The bulbs planted were 7 centimeters in size, set 21 to the row. Note the character and arrangement of the reproduction. FIG. 4.—Same as Figure 3, with clumps cleaned and separated. Note that although these have reached mature size, none of them flowered this year. Each 7-centimeter bulb planted has become 12 to 13 centimeters in circumference and produced another which will reach flowering size in another year, although all may not flower. This variety has an appealing flower and is a good reproducer, two characteristics which make for commercial quality.

FIG. 1.—THE MARKER IN OPERATION.

FIG. 2.—THE OPERATION OF PLANTING TULIP BULBS.

The two men on the right are marking off a bed. One operation is not shown, i. e., covering the bulbs. The soil from the next bed on the right is transferred to cover the bulbs which the boys are setting.

PLANTING TULIPS.

placed from these containers. Sometimes, however, those planted 14 to the row are also strewn along the bed and placed from there. (Pl. VI, Fig. 2.)

Bulb setting, while appearing simple, is a job requiring a great deal of dexterity. Boys commonly succeed better at it than men, and some boys are able to place twice as many bulbs as others.

With a crew of two men to shovel and rake, it is desirable to employ two to four boys to place the bulbs. However, two capable boys and two men make an ideal planting crew.

In the mucking,[1] as in all else in this work, a regular system is followed. Three shovelfuls across the bed, provided the soil is in good tilth and hangs together well, remove sufficient soil to get the required depth. The mucker generally takes a shovelful from the right side, another from the left, and then one from the middle. This method is continued clear across the bed.

Usually in the soils used in the Bureau of Plant Industry experiments the man who rakes down the beds follows and throws out a small shovelful of earth from each edge of the bed. He works in the partially opened bed and faces in the opposite direction from the regular mucker, doing this work and keeping tally. One of the boys who is planting keeps a record of the number of rows by setting a stake. He calls off the numbers of the rows and of the bulbs planted to the row, which the raker jots down in his planting book each time a change of size is made. This record is simply a skeleton, but with a little computation it gives the total number of bulbs planted and the number of each size. From this record the grower experienced in tulip production in any region may predict with considerable accuracy what can be turned off at the next digging. The row is one of the most useful units of record in bulb culture. Some record of this nature is considered desirable, if not absolutely necessary, not only in experimental but in commercial bulb growing also.

BULBS SET ACCORDING TO SIZE.

The bulbs are set according to size; the larger the size the fewer the bulbs set in the row, the principal thing being to get as nearly as practicable the same quantity of plant material in equivalent areas.

The practice adopted in the investigations of the Bureau of Plant Industry doubtless could be improved; but it is approximate, fits in fairly well with the facilities for sizing, and varies but little from true accuracy. At present, with the fertility of cover crops on virgin soil, no fewer than 11 bulbs are planted to a 36-inch row. All bulbs larger than 10 centimeters are given this spacing and are set upright. The next size for planting is caught by the 8-centimeter sieve. These bulbs are planted 14 to the row. The bulbs caught in the 7-

[1] The shoveling.

centimeter sieve are planted 21 to the row, and the 5-centimeter bulbs are planted 35 to the row. All bulbs which pass a 5-centimeter sieve are strewn along, about 50 to the row. The fourteens, twenty-ones, and thirty-fives are planted in 7 clusters of 2, 3, and 5, respectively.

THE PLANTING RECORD.

The record made at planting time furnishes the basis for all computations on the grower's inventory. In bulb culture the grower is constantly dealing in large numbers. At present we are putting little short of 350,000 bulbs on an acre. It is desirable to have a reasonably accurate estimate of these without the labor of actually counting them. This is accomplished by getting a count of the number of rows of each size planted. To accomplish this, one of the boys who sets bulbs keeps the tally and when a change of size is made calls the number of rows of each size planted to the foreman of the planting crew, who jots down the number in the proper space in a notebook previously ruled. The form of this record is shown in Table 1.

TABLE 1.—*Form of the planting record.*

Inventory No.	Name of variety.	Number of rows planted of each size.				
		11 to row, above 10 cm.	14 to row, size 8 cm.	21 to row, size 7 cm.	35 to row, size 5 cm.	50 to row, size under 5 cm.
479	*Artus*	*75*				
490	*Couleur Cramoisi*		*162*	*82*	*86*	
493	*Duchess de Parma*	*151*	*64*	*23*	*32*	
327	*Faust.*	*5*	*13*	*8*	*8*	*12*
334	*General Köhler*	*29*	*10*	*7*	*4*	*5*
231	*Jassi Prince William*	*19*	*8*	*6*	*4*	*2*
617	*Kaufmanniana*		*2*	*1*	*3*	
526	*McKinley*	*327*	*184*	*102*	*90*	*104*
410	*Professor Trelease*	*22*				
418	*Rev. H. Ewbank*	*45*	*13*	*10*	*4*	*5*
538	*White Swan*	*163*	*62*	*109*	*64*	*95*

Adding the horizontal column gives the total number of rows planted to any one variety. This can also be obtained by multiplying the number of running feet of a 3-foot bed by 2, since the rows are 6 inches apart. To arrive at the number of bulbs of any size planted, the figure representing the number of rows must be multi-

plied by the figure at the head of the column. The total number of bulbs of any one variety planted is the sum of the product of the number of rows of each size multiplied by the number of bulbs planted to the row in each size.

SIZES AND QUALITY OF BULBS USED FOR PLANTING.

The quality of one's planting stock can not be designated in centimeters any more than by any other known standard of measure. There are so many factors entering into consideration as to make the grower's planting stock the most variable element in the production of tulip bulbs. There is one idea which the producer should always have in mind, i. e., he should strive to set for the next season's turn-off as large a percentage of sizes which will mature in one year as is compatible with the production of sufficient planting stock of the same character for the succeeding year. In other words, it is the smallest planting bulbs which will grow to maturity in one year, which are set and dug but once, that will yield the greatest net cash returns, and it should be the grower's aim to use in his planting as large a percentage of such bulbs as possible.

When any stock is scarce or hard to get and it is desirable to increase the planting, the grower may find it to his advantage to plant every bulblet he has, in which case his planting bulbs may vary from 3 to 14 centimeters or more in size. In the general run of the business, however, bulbs below 5 centimeters in size should be discarded, because the length of time it takes to bring them to maturity cuts down the profits too much. Practically all bulbs of 5 to 7 centimeters, under good cultural conditions, should reach merchantable size the second year, and those 8 centimeters and over should reach maturity in one year.

Often the commercial grower reserves his toppers [2] and plants them. It is from these that he gets his greatest proportion of increase. But there is as much psychology in this practice as there is in selection. The grower can not afford to turn off the small percentage of oversized bulbs to the consumer, who may be ignorant as to what the size of the bulbs should really be and is likely to gauge the quality of his receipts by the quality of the small percentage of top-sized bulbs. These toppers, on the other hand, while giving a merchantable bulb the next season, together with a numerous progeny, are expensive to grow, for the reason that they are large and require a greater space than the smaller bulbs which are just large enough to come to maturity in one year and be turned off.

The proper size to plant in order to obtain a mature bulb at the next digging is dependent directly on the fertility of the soil and inversely on the thickness of the planting.

[2] The largest bulbs of a variety.

The grower, of course, will be governed in his planting by the stock which he has on hand. If his turn-off of bulbs has been close, his planting stock will be proportionally reduced in size. It will take a little time for him to determine just where the dividing line lies between his merchantable stock and a sufficiency of advantageous sizes for planting.

DISTRIBUTION OF PLANTING MATERIAL.

As stated on another page, the object of the close sizing of planting stock is to get an even distribution of plant material over the ground. The sizing in the experimental work considered here has been an approximation, possibly closer than will obtain in commercial planting, but by no means exact.

In order to test the closeness of the approximation the following tabulation was made at the time of planting in 1919. The variety used was Artus.

1 bushel of bulbs under 5 centimeters planted 50 to a row covered 137 rows.
1 bushel of bulbs of 5 centimeters planted 35 to a row covered 119 rows.
1 bushel of bulbs of 7 centimeters planted 21 to a row covered 129 rows.
1 bushel of bulbs of 8 centimeters planted 14 to a row covered 135 rows.

The test was made in the field at planting time with the stock as sized in the bulb house. Exact comparability would require that 1 bushel of bulbs should plant the same number of rows of all sizes. Of course, perfect uniformity with such inequalities in the sizes employed can not be attained.

ADVANTAGES AND DISADVANTAGES OF THE BED SYSTEM OF PLANTING.

In the United States there is always an effort to eliminate as far as possible hand labor in all farming operations. We perform by machinery many operations which the foreigner finds it cheaper to do by hand. One of the stock arguments against the bulb business in the United States has been the expense entailed by the very large proportion of hand labor required. The bed system means hand labor. (Pl. VI, Fig. 2.) Whether the bulb business in this country can be divorced from it remains to be determined. It is not the purpose of this bulletin to decide which is the better way, but simply to show that bulbs have been produced in this country, to tell how the growing has been done, and to point out the fundamental operations involved in their production. To determine whether there is a method superior to the bed system will require much experiment, and the question may not be settled for years; indeed, it would not be well to try to establish at this time any degree of finality in methods.

In the use of the bed system a maximum quantity of material can be grown on a given area. The production of bulbs as practiced

under this system is one of the most intensive of horticultural practices, and there is a decided advantage in thick and exhaustive cropping. The land over the whole bed is fully occupied by the plants, and there is a minimum of vacant area in the paths between the beds, probably not more than 6 or 8 inches of unoccupied soil in the 4 feet needed by the work incident to culture and handling.

In the production of tulip bulbs, to a greater degree than with the narcissus, gladiolus, and many other bulbous stocks, care in handling the plants is a very important factor. The main advantage of a row system of planting is to allow the use of some implement for keeping down weeds and cultivating, but in tulip culture the use of even a wheel hoe close enough to obviate the necessity of hand weeding is likely to prove detrimental. The leaves are stiff, rigid, in the way of tools, and easily bruised, and mechanical injury of any kind to the growing plant is conducive to the development of the fire-disease organism which, together with the loss incident to a thin planting on heavily fertilized soil, would at least go a long way toward offsetting the advantage gained in handling the crop on a cultivated-row basis.

The bed method of planting, if well done, has a decided advantage in that the bulbs are more easily set at a uniform depth. They are planted in a geometrical design, and each can be found without surface indications when the first row in the bed is located. These are very important considerations in a crop in which uniformity of growth and delicacy of handling are demanded.

The advantage of row planting with implement cultivation has not yet been made clear. Implements can not well be operated closer than 3 inches to a row of tulips. This necessitates the hand weeding of 3 inches on each side of the row. In beds the rows are 6 inches apart. It appears from this that the hand labor for a given length of row is identical whether the planting is 6 inches or 2 feet apart, and the closer planted bed holds three or four times as many bulbs as the other per unit of area. Some employ a bed 8 to 10 inches wide with about a 16-inch space between.

With these few observations, the question as to which method is best is left open, with the statement that so far as experience goes the production of tulip bulbs adapts itself to the intensive rather than the extensive method of culture.

For the present the subject of planting or digging tulips by machinery may be dismissed. No machinery for either of these operations has yet been invented.

WHEN TO PLANT TULIPS.

The best time to plant tulips is before the middle of September, but through October is all right. The main objects of digging the bulbs

each year are to renew the fertility of the soil, to separate the merchantable bulbs from the others, and to distribute and rearrange the remaining bulbs in order to prevent crowding. These things accomplished, the bulbs are better off in the ground than in any storage that can be given them.

The practice of the Department of Agriculture has varied. In some years planting has not been completed before December, but for the past three years the digging has been mainly done in July and the planting in August. Early planting is to be preferred.

On the other hand, the tulip bulb is very adaptable and may be planted with a degree of success as late as the ground can be worked. Indeed, the bulbs may often be carried over winter in storage, planted in early spring, and the stock saved.

In practice the grower will begin planting as soon as he has finished digging and cleaning. The exact time of starting and finishing each operation will depend upon the season, the amount of digging to be done, the labor available, and other factors that enter into the economy of farm operations.

TREATMENT OF THE BEDS AFTER PLANTING.

The surface soil of the planted bed is left as it is dropped from the shovel until the planting is done. It is soon settled naturally by a shower of rain. Late in the season, or as soon as weeds begin to grow, cultivation begins and is continued, to kill successive crops of weeds and smooth off the surface, until winter sets in and prevents further work on the ground. In tulip culture, economy requires a maximum of cultivation before the plants appear above ground and a minimum afterwards.

This cultivation in autumn is done in various ways. The most expeditious method is with a wheel hoe which is operated with weeder knives attached, usually across the beds. Commonly this is the only tool used.

After two or three weeks there need be no hesitancy in walking over the beds enough to do this cultivating, but immediately after planting the beds should be walked on as little as possible and no more than is necessary at any season.

MULCHING.

The most approved practice requires clean culture for tulips. The one objection to a mulch on tulips is the danger of the spread of the fire disease caused by the fungus Botrytis, which may be very destructive wherever the conditions are such that both the surface of the ground and the plants are continuously wet for days at a time.

Since tulips are grown mostly in regions where low temperatures and humid conditions obtain during the growing season, it will be much safer for the grower to practice clean culture.

SPRING CULTIVATION.

In tulip culture tillage of the soil with implements after the plants are above ground is not generally considered practicable. In the present location of the tulip experiments of the Bureau of Plant Industry it has been scarcely possible, on most of the soils, to do any cultivation after winter sets in until about the time the early varieties are done blossoming. In spring, therefore, cultivation has not gone beyond keeping the paths free of weeds with a wheel hoe and weeding the beds mostly by hand when weed growth was bad. One tool which meets with greater favor than any other with the men when work on the beds is imperative is a light hoe with a blade only 3 inches wide. With care this can be operated to remove the weeds between the bulb rows while standing in the paths. In reasonably clean soil the common 5-pronged hoelike cultivator can be used to good advantage when reduced to three teeth set to a spread of 2½ to 3 inches. This can be drawn between the rows to a depth of about 2 inches to very good purpose in aerating the soil which has been packed by the winter rains. In the experimental work, however, cultivation of the tulip beds in spring has not been generally practiced.

It is absolutely essential to good results that weeds be kept down. The work of weeding is amply compensated by the saving of labor at the time of harvest, to say nothing of preventing the accumulation of weed seed in the soil and the interference with the crop where weeds are bad.

Proper handling of the soil will reduce the weed nuisance to a minimum. With ground kept continuously well tilled and free from weeds through late-autumn cultivation of the beds, and with a good stand of vigorous tulips, weeds become a minor factor in tulip-bulb production. This experimental work is on new ground, and it is far from free of weeds. In spite of this, last year only 1½ man days were spent pulling weeds from the beds on an acre planting.

AGE OF FLOWERING BULBS.

The "age of flowering bulbs" is in reality a misnomer, but is used because so often heard in connection with the bulb business. All tulip bulbs, whether large or small, are in reality of the current year's production and therefore not over one year of age. The tulip produces a new bulb or bulbs each year just as truly as the gladiolus or freesia corms are renewed by an entirely new structure each season. (See Pls. III, IV, and V.) For this reason the flowering quality of

the bulbs is measured by size rather than by age. However, if bulblets below 5 centimeters in circumference be planted, it can be said with confidence that with most garden tulips some of these will blossom the second and the remainder the third year.

BLINDNESS.

A blind tulip is one which has reached flowering size and may or may not produce a stem, but does not flower. It may or may not have flowered the previous season. The causes of blindness in commercial bulbs are varied. It may be due to slight heating in the pack in transit, to too high a temperature at the time the plants are rooting,[3] or to improper temperature or moisture conditions at the time the bud is coming to view, to escaping gas, or in some sections to heavy infestations of plant lice.

It not infrequently happens that sufficient heating occurs in transit to kill the flower while the bulb is little if at all injured for growth. The only way to detect this defect is to cut a bulb open. A dead flower can easily be recognized. No case is known to the writer where bulbs of proper size and firmness have been grown with no flowers in them. The blindness has invariably been brought about by treatment after digging. When blindness occurs in bedding tulips the defect is most commonly traceable to heating somewhere in storage. When it occurs in forced stocks the trouble may be the same or it may be due to improper handling. It may be accepted as axiomatic that a tulip bulb of proper size and ordinary firmness has a flower in it and if properly handled will produce that flower.

RELATION OF SIZE OF BULB TO SIZE OF FLOWER.

In general the size of the flower in any variety is proportional to the size of the bulb. It takes a certain size of bulb to produce a flower, and the larger and more perfect the bulb the larger and better the flower. It is under conditions of starvation and crowding that flowers as well as bulbs become small, and some varieties will reduce the size of their flowers beyond anything to be thought of in other varieties. Lack of proper fertility over a period of years will often cause excessive splitting of bulbs. Poor fertility and neglect will also give much smaller flowers than will be found under conditions of careful cultivation, although all the progeny may be planted, from a 3-centimeter bulblet up.

Flowers of Artus under poor fertility may be not over three-fourths of an inch in diameter when fully opened, but in well-grown stocks the smallest flowers are never so small.

---

[3] This applies to blindness under forcing conditions and also may apply to bedded tulips in the extreme South.

EARLY MATURITY AFFECTING THE BLOSSOMING SEASON.

It is very important for the grower to realize that the tulip bulb is not inactive during the so-called dormant period, when the bulbs are out of the ground. (Compare the bulbs in Pl. VII, Fig. 3.) Profound changes take place in the bulbs on the shelves, which though invisible, are no less important than the development of leaf stem and roots the next season. Upon these changes largely depends the time of flowering the next season. Consequently, with a varying dormant season there will be a corresponding variation in the next flowering season. But with given conditions during dormancy, the earlier the bulbs mature the earlier they will flower the next season. Besides, under our Puget Sound conditions, bulbs dug and kept on the shelves less than two months flower earlier than those left undug

It will readily be seen that stocks which mature early will blossom earlier the next season than those which mature later. A difference of a few degrees of temperature for two months during storage, however, will greatly advance the development of the flower spike and consequently cause the stocks to blossom earlier. This principle forms the basis of the early flowering of the Dutch Prepared bulbs which have been put on the market in recent years.

Some experiences with early-maturing stocks are to the point. Several varieties of single early tulips were salvaged from the beds on the grounds of the Department of Agriculture in April, 1919. They were heeled in to ripen, dug, and dried by June 15 in the climate of Washington, D. C. They were then shipped to Bellingham, Wash., and planted with the other stocks of the same varieties in August. The next spring these all flowered from a week to 10 days ahead of the home-grown Bellingham stocks. Indeed, Keizerkroon flowered so early that it was 10 days after it was in full flower before the petals could spread because of low temperatures. This is an extreme case, but illustrates well the effect on the next season's blossoming of early maturity coupled with high temperature at the time of curing.

In the purchase of stocks the tulip grower will find a great variation with the locality in which the stocks are grown, as well as with the condition under which they are handled during the so-called dormant period.

SALE OF FLOWERS.

The sale of flowers has little place in connection with tulip-bulb production. The production of flowers and of bulbs for sale are two separate ventures and are largely incompatible.

For the flowers to be of value they must have long stems. To secure these in any tulip requires the removal of leafage, which is not compatible with proper bulb production.

Some growers follow the practice of cutting the stems below the upper leaf, thus removing a minimum of the feeding surface of the plant; but even this interferes with the best production of bulbs. It is not good practice in bulb production, and tulip bulbs will gradually deteriorate under this treatment.

The practice may be conducted with less injurious effects with the Darwins and some other single late varieties than with other tulips, for the reason that when well grown these plants have a foot of stem above the top leaf. Cutting above this leaf can be safely indulged in, and the flowers will be decorative, provided greens from some other source be supplied.

REMOVING THE FLOWERS.

In the production of tulip bulbs it is imperative that no flowers be allowed to fall to pieces on the beds or any seed vessels allowed to mature on the plants.

The tulip stem is brittle, and a quick, abrupt bending of it between the thumb and forefinger will snap it off with certainty. (Pl. VIII, Fig. 1.) The operation should be performed before the flowers drop their petals, and all flowers and portions of flowers should be carried out of the bulb fields.

In regions best adapted to tulip culture the dropping of the petals on the foliage and on the surface of the ground during humid weather is fraught with danger. When this is allowed to take place, the decaying petals if they remain damp all day form the best kind of medium for the development of the fungus Botrytis, the cause of the fire disease. It is therefore the practice of bulb growers to remove all flowers of tulips before the petals begin to fall.

Preferably two men work together, one on each side of the bed, and snap off the flowers with an inch or two of stem, placing them in a pail or any convenient container, to be emptied into larger receptacles or carts in the roadways and later removed from the bulb fields.

In many regions where tulip bulbs can be successfully grown the danger from fire injury is reduced to a minimum if the general atmospheric conditions are such as to cause the petals to dry up rather than to decay on the plants or on the ground. Even under these conditions it is necessary to remove the flowers, for the reason that practically all tulips produce seed profusely, and when they are allowed to do so the production of bulbs is correspondingly reduced.

The time at which the flowers are removed may vary. It is customary to remove them after they have faded and before the petals fall. They can just as well be removed in the bud, but there is a certain advantage in public appreciation and local enjoyment

in leaving the flowers as long as they are in good condition. There is the further advantage to the grower that he is able to true up his stock.

WHEN TULIPS ARE RIPE.

Generally speaking, tulips are ready to dig as soon as the tops have dried down in June. The precise time when they should be lifted, however, will depend somewhat upon the variety and varies slightly with the season. In the single early varieties it is not necessary to wait until the tops are dry. When they have yellowed well and the upper leaf has dried, most of the varieties may be lifted. The color of the outer coats is a good criterion. The bulbs should be dug as soon as the outer coats have turned to the rich brown so characteristic of the tulip. The sooner they are dug after maturity the better the coats are preserved. As a rule, tulips should be lifted just as soon as possible after the proper time comes, and this is especially true of the single earlies and Darwins. The experience of the Bureau of Plant Industry with single late forms, such as the Gesnerianas and Picotees, is that they are sometimes not ready to dig for a week or more after the tops die down. Often the bulb coats are perfectly white at the time the tops dry. This is especially noticeable if the soil is poorly aerated. The one important consideration as regards the time of digging is to do the work at the time when the coats will be best preserved. This means digging early. It means digging as soon as the plants are far enough advanced for the coats to be perfectly formed and to assume their normal color upon drying. If digging is long delayed, the coats deteriorate and the bulbs lose this natural protective covering. Often bulbs go into the bulb house with half of the coats white. If the soils were sandy loam, the coats would form earlier and be stronger.

The moisture, heat, depth of planting, and nature of the soil all affect the maturity and coloration of the coats. With lack of moisture they dry off quickly and mature. Heat has about the same effect. In sandy soil the coats form and brown up better than in heavier loams. If the bulbs are planted shallow on heavier soils, the coats will brown up quicker and the plants be ready to dig earlier than when planted deeper.

DIGGING TULIPS.

Plate IX, Figure 1, gives a better idea of the operation of digging than a long description. The men work on their knees and take out the bulbs with a small short-handled spade. (Pl. X, Fig. 4.)

The operation of digging tulips and other bulbous stocks, while very simple, is one which is capable of being highly developed. The good digger is active, quick, and alert in his movements. He operates his digging tool with a positive movement. He fixes in

mind the planting scheme, which enables him to pick up the loosened bulbs and drop them in the tray with no lost motion.

The beds when ready to dig have been hoed off, and there is nothing to indicate the position of the bulbs. The first row in the bed may vary as much as 4 or 5 inches in its position. In starting to dig, therefore, it is necessary simply to find one bulb in the first row. This is done by scratching off the soil over 6 inches or more of the surface until the nose of a bulb or perchance the remains of some of the stems are seen. It is then a simple matter to dig behind the row straight across the bed and remove the bulbs.

The digger always keeps a furrowlike trench in front of him in the position of the last row dug. In starting on a new row he strikes back 6 inches with his spade. The bulbs are located in the middle of this 6-inch space. With a few short, sharp jabs with his spade he removes 2 to 3 inches of the upper layer of soil in a 6-inch strip across the bed. This invariably exposes some of the bulbs and visually demonstrates the exact position of the row. This operation of uncovering proceeds from right to left or from left to right across the bed. The digger then begins back on the right or left again. With another thrust of the spade and again pulling the dirt and bulbs toward him he loosens the bulbs for a 6 or 8 inch section of the row. The bulbs are then placed in the screen-bottomed trays and the rest of the row removed in the same way, and so on with the next row. In some cases, especially with large bulbs, the whole row of bulbs is loosened after being uncovered before any of the bulbs are picked up. These directions for digging appear more complicated than they really are. The operations are simple and quickly made.

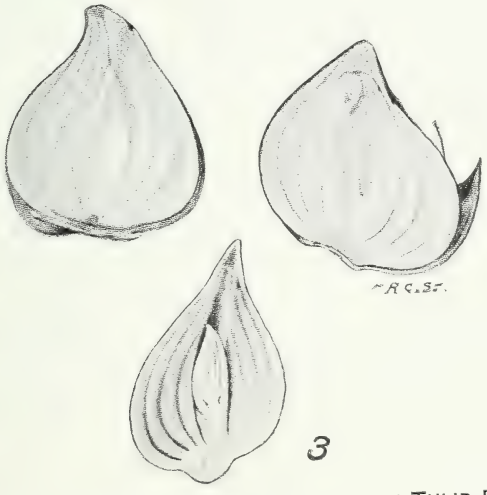
The uncovering of the row before loosening the bulbs seems to be advantageous on heavy soils, but on the lighter soils the loosening of the bulbs is accomplished with one movement of the digging tool.

The bulbs come out of the ground for the most part in clumps. The digger lifts the whole clump without any attempt to get it free from dirt and places it in the hand screens described elsewhere. These receptacles the digger pushes ahead of him over the bed as he digs. When the tray is two-thirds full, the contents are sifted lightly to remove the loose dirt and the bulbs poured into the lug boxes and taken to the bulb house.

In case the quantity of the variety being dug is large or the bulbs very damp, it is often advisable to employ a large shaker, like that shown in Plate IX, Figure 2. This is operated by two men, and about a bushel of bulbs is cleaned of loose dirt at one time.

IMPORTANCE OF CLEAN DIGGING.

Wherever bulb culture is taken up in earnest great care should be exercised to get all the bulbs out of the ground. Aside from the



GROWTH CONDITIONS AND FIRE-DISEASE OF TULIP BULBS.

FIG. 1.—Darwin tulip clump of bulbs with improperly filled coats due to bad cultural conditions. FIG. 2.—A dwarfed seed pod of single late tulip *retroflexa*, showing the resting stage (sclerotia) of the fire-disease fungus (Botrytis). FIG. 3.—Single early tulips in vertical section, showing (above) the absence of flower indications in July when the bulbs were dug and (below) the well-developed flower later in the season.

FIG. 1.—REMOVING FLOWERS FROM THE BEDS OF SINGLE EARLY TULIPS AS THEY FADE.

FIG. 2.—GENERAL VIEW OF A CREW CLEANING TULIP BULBS AROUND A LONG TABLE.

Cleaning the bulbs is usually a rainy-day job or a rush one between digging and planting time.

FIG. 1.—THE OPERATION OF TAKING THE BULBS OUT OF THE GROUND.

There are no surface indications, but the bulbs are in rows 6 inches apart. The digger is starting after the next row.

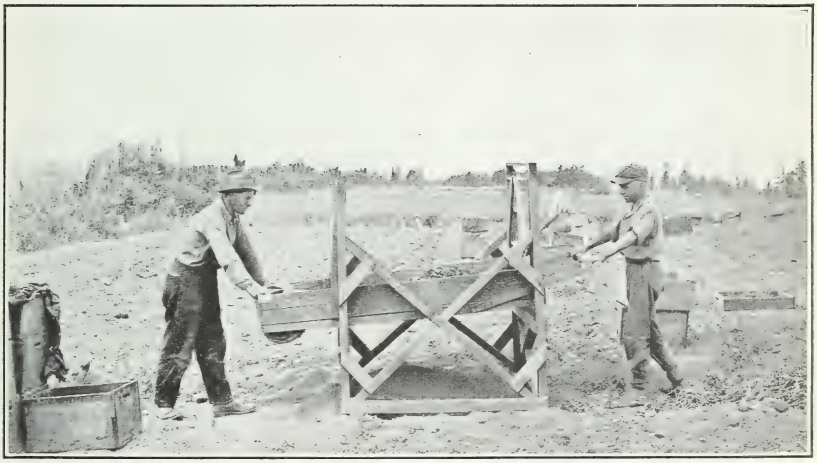
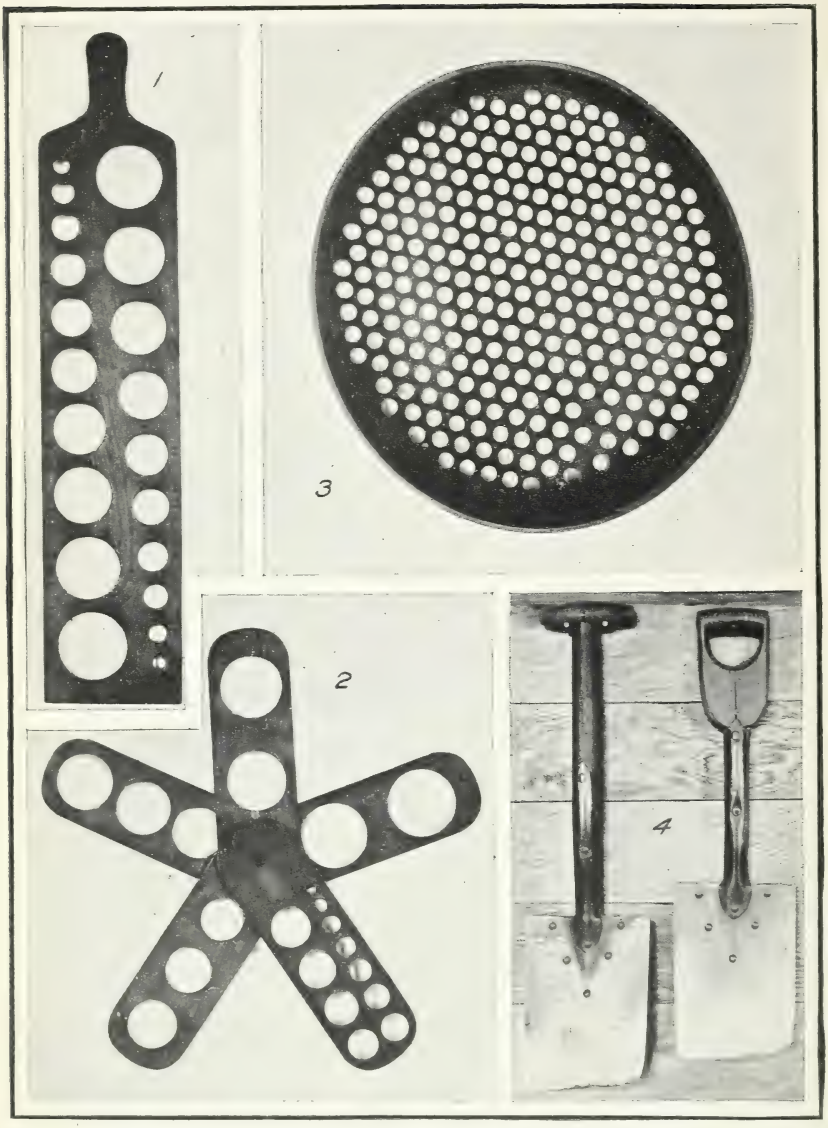


FIG. 2.—SCREENING TULIP BULBS.

In digging large lots the bulbs are screened after digging in a machine such as the one here illustrated, about a bushel at a time. The tray in front of the boy in Figure 1 is shaken by hand to remove the dirt when the lots of bulbs are small.

DIGGING TULIPS.



BULB IMPLEMENTS.

FIG. 1.—A bulb caliper. FIG. 2.—Another form of bulb caliper. FIG. 3.—A bulb sieve with bottom of rawhide. FIG. 4.—Two forms of digging spades. These are the commercial boy's spade with the handle shortened. Note that the blade is wide and flat and the shank quite straight.

economic loss of the bulbs left in the ground there is the added disadvantage of fouling the land. There is no crop which will foul the soil worse than a bulbous one if the digging is carelessly done. The undug bulbs persist. They come up as weeds in the next crop and mix varieties in subsequent years. It is a good practice to go over the fields about blossoming time and dig out all bulbs of the previous crop. This can be attended to at the time the general roguing occurs.

ANNUAL DIGGING IMPERATIVE.

In the commercial production of tulip bulbs the writer has seen no condition under which it is economically advantageous to leave the bulbs undug for two seasons. Such a practice can not be defended except on the basis of expediency; never on the basis of quality or production. The tulip is a gross feeder, and the commercial varieties are so productive in increase of small bulbs that when not lifted annually they are crowded to such an extent that they deteriorate in size and are not merchantable when lifted. (Pl. III, Fig. 2.)

The only condition under which it is considered at all permissible to leave tulips undug is when stocks are being worked up from small sizes and no marketing is contemplated at the next digging. Even in such a case, when the increased weed burden, greater danger of injury from field mice, greater loss from winter heaving, and more laborious cleaning are considered, it is a questionable practice.

It is estimated that the cleaning of biennially dug bulbs takes about three times as much labor as bulbs dug annually. The accumulation of old coats and the thick mat of roots make the cleaning a very laborious process.

DROPPERS.

Tulip bulbs, like many other bulbous stocks, when not planted at the level which they like seek that level by a special process which has been named "dropping." (Pl. XI, Figs. 3 and 4.) This signifies that in the usual artificial handling the bulbs are not planted at the depth which is natural for them. They therefore seek the level which is best suited by dropping or, in some instances, when planted too deep, rising to it. This shift in depth is more likely to occur with the smaller sizes of bulbs and is more prevalent in some species than in the garden varieties.

The change of location is accomplished by a simple contrivance which looks exteriorly like a short stem connecting the location where the bulb was set with its newly acquired position. In reality this connection is simply a fold in the leaf stem which surrounds the new bulb. This fold lengthens, forming a tube, in the end of which the new bulb develops. At times the whole original bulb drops, but most commonly some bulbs are formed in the original situation and

one dropper, the roots always indicating the original position but no roots appearing from the dropper, which is always more heavily coated than the normal bulbs.

THE BULB HOUSE.

The house in which tulips are handled should have provision for the perfect control of both ventilation and light. The heat conditions will be subject to the natural fluctuations of the temperature of the region.

The conventional structure for this purpose has not less than one-third of its wall space made up of partly glazed doors extending from the floor nearly or quite to the ceiling. The interior arrangement is such as to admit of storing the bulbs in layers 4 to 5 inches deep. This is accomplished by the use of stationary shelving or trays, as shown in Plate XII, Figures 1 and 2, and Plate XIII, Figure 2.

The shelves may be built in, about 15 inches apart and 2½ feet wide. They are usually constructed 5 feet wide, with a partition in the center, thus making two shelves, back to back as it were. Between these double rows of shelves are alleyways about 3 feet wide, to permit getting the bulbs in and out.

Trays are stacked in racks made to receive them. They have an advantage over the shelves in that they can be placed closer together, thus economizing storage space; but the trays have the disadvantage of requiring a greater width of alley than the solid shelf. The alleyways for the trays must be wide enough to permit carrying through them the trays loaded with bulbs.

The size of the tray will depend upon a man's notion of convenience. Those employed by the Bureau of Plant Industry at present are 4 feet square and 2 to 2½ inches deep. They should always be constructed of matched lumber, to prevent even the smallest bulbs from falling through and thus mixing stocks. The Plant Industry tray is a 2-man tray; a few trays, however, 2 by 4 feet, can be handled by one man. Some prefer a tray about 3 feet square, which can be handled by one man.

One grower has made his trays 3 by 9 feet. (Pl. XIII, Fig. 2.) These have 2½-inch blocks under their corners, so they can be stacked one on top of the other in piles without racks. These have the advantage of economizing space, but the disadvantage that a tray can not be removed at will for use or for examination without moving all above it. This form of tray is better adapted to large than to small quantities of bulbs of one variety.

THE MANAGEMENT OF THE BULB HOUSE.

Given control of the two factors of ventilation and light, it is a comparatively simple matter to cure tulips properly in practically any region in this country that is adapted to growing tulips. Dry

late-summer and autumn conditions are an important asset in the curing of bulbs both in and out of the ground.

If the bulb house is filled rapidly and to its capacity, there is a proportionately large amount of moisture to be evaporated and gotten rid of at one time. Usually the bulbs come into the house rather slowly, and some should be dry and ready to clean before the last of the crop is dug. It is therefore advantageous to fill first one portion of the compartment devoted to tulips, so that the ventilation can be lessened at one end and put on fully where more needed.

On Puget Sound the ventilating doors of the bulb house usually stand open or partly open during the greater part of the day and are closed at night. This treatment will be all the more emphasized if the location is near the coast. Even 3 or 4 miles inland less ventilation will be required. The advantage of the closed house at night is to assist in keeping up the temperature, which in this location is low.

It should be remembered that tulip bulbs must not dry out rapidly. The curing process is not simply one of evaporating the moisture, but this moisture evaporation is the physically obvious indication of very complicated life processes taking place in the bulbs on the shelves. The drying out, therefore, should not be too sudden. If the bulbs are dug at the proper time to preserve the coats, they will not have turned color completely when brought into the bulb house. In this condition they should not become dried out and ready to handle in much less than two weeks. A little longer time does no injury, and 10 days might be enough.

The directions that can be given for handling bulbs in the bulb house are necessarily very general. The work is one of those jobs that the grower must learn to do by doing. He must learn to know his stocks and to know what they need from day to day.

This does not at all mean that the matter is complicated. It is simple when compared with handling vegetatively vigorous plants in the greenhouse. Indeed, for the past three years at the Bureau of Plant Industry bulb house 300,000 tulips, besides the complement of planting stock, have been cured annually, with little control of ventilation. Operations have been carried on in an open shed with fair success, but the bulbs were cleaned as quickly as possible and then smothered with buckwheat hulls or old sacks in order to protect them from excessive desiccation and light.

"CURING" THE BULBS.

The word "curing," as applied to tulip bulbs as well as to other flowering bulbous stocks, is a misnomer. "Curing" bulbs is an artificial and unnatural process necessitated by commercial handling and not a process required by the stocks themselves. The more

closely, therefore, the conditions of nature can be imitated during the time the bulbs are out of the ground the better they will be preserved. It should be constantly borne in mind that we are dealing with plants whose natural environment is the soil, the multitudinous influences of which are very difficult to imitate. This curing consists simply in drying the bulb clumps as they come from the ground until the old coats appear dry to the touch. The bulbs are dried sufficiently so that mold will not develop. The whole process amounts to striking a balance between an excessive moisture which will allow the development of molds and other decomposition fungi on the one hand and too great a desiccation of the bulbs on the other.

SHELF REQUIREMENT.

The square feet of shelf space needed in the bulb house will vary greatly with conditions. The main factors which influence it are the moisture content of the bulbs when placed in storage, the control of ventilation in the house, and the general atmospheric conditions.

Under conditions which make for rapid desiccation the bulbs can be piled higher and consequently require less room. As a rule, tulip bulbs can go on the shelves 4 to 5 inches deep. (Pl. XII.) As concrete examples of actual performance in this respect Table 2 gives useful information on actual operations wherein the difference will be seen to vary more than 50 per cent.

TABLE 2.—*Space required by tulip bulbs of the Cardinal's Hat variety when growing in the field and when "curing" in the bulb house.*

Rows.	Growing space.		Number.		Weight (pounds).			Shelf room used in bulb house (square feet).
	45-foot beds.	Area.	Salable.	Planting stock.	Salable.	Planting stock.	Total.	
3,384.....	37⅜	About one-fifth acre.	22,000	70,000	1,620	1,120	2,740	260

In 1919 the merchantable turn-off of Cardinal's Hat was 22,000 bulbs, a number large enough to afford trustworthy figures of the space actually employed for handling. In order to have a reliable conception of the bulb-house space, its relation to field space, weight, and number of bulbs is necessary.

The bulbs were dry when dug and of prime quality. Their coats, though, were somewhat cracked, and they were piled higher than usual to get added protection from atmospheric influences. Concerning the 70,000 planting stock it may be said that about 11,000 of these bulbs were below 5 centimeters in circumference and were discarded at planting time.

The drier the situation the less shelf room is required for a given quantity. Indeed, it is found that the new location of these experiments on Puget Sound requires less shelf room for a given area of ground planted than did the old one, although the yield is greater. This is due to drier, better drained soils and to the better atmospheric conditions that exist farther back from the coast.

In handling an acre of tulips in 1920, the bulbs were brought into the house in rotation. The shelf room occupied may be accepted as rather more than is necessary to hold a good crop of these bulbs for the proper curing of stock on such an area at one time under commercial conditions. In practice, when digging is not continuous or rapid it is possible to clean and condense the stocks on the shelves and thus occupy some of the shelf space more than once.

A total of 180 trays 4 feet square held the bulbs from 1 acre for curing in 1920. This in round numbers is 2,880 square feet of shelving, which was ample for a 1-acre crop. It is thought that 2,000 to 2,500 feet of shelving for an acre of tulips under commercial conditions where comparatively large lots of few varieties are handled would be ample.

It will be seen that over twice as much shelf space proportionally was used in the 1920 season in handling an acre as was required the year before for a single variety, Cardinal's Hat, on solid shelves. It will always be true that solid shelving, although not so handy, will be more heavily loaded per square foot than trays. It is also to be noted that in 1919 the crop was much drier when dug, and this particular variety really could have been cleaned without any drying.

CLEANING TULIP BULBS.

The separation of the bulbs from the clumps and the removal of the old coats preparatory to sale and resetting of the stocks are at present done by hand wherever tulips are grown. The work is so variable and of such a nature that it is not clear how a machine can be made to perform the operations successfully, but there are a number of devices which can be used greatly to assist in the process. The operations at Bellingham, Wash., where more than 250,000 tulip bulbs a year have been turned off, have given a fairly good opportunity to study the requirements rather closely.

Emphasis should be put on the fact that if possible tulip bulbs should be cleaned before they are too dry, for the reason that the coats are much more likely to be preserved from cracking in the handling and exposure to light incident to the cleaning if they are not too thoroughly dried out. There is always more or less abrasion, and it is necessary for the cleaners to have good light to work by. The bulbs are consequently exposed for some time to detrimental influences during this operation. Of course, one who grows bulbs on

a small scale and is not selling can very advantageously leave them in the old matrix until the time of planting. In this case the cracking of the coats is not so serious a matter, and the presence of the old matrix may actually be a protection to small lots stored on a makeshift basis. With the commercial grower, however, the case is very different. He must preserve the coats, for more than one reason, and he must separate his merchantable bulbs from his planting stock without unnecessary delay, for the market is always impatient for its bulbs, and the planting season is rapidly approaching.

When the bulbs have reached the proper condition they are removed from the shelves or trays to large cleaning tables, where several men or boys work them over, or the cleaning is done directly from the trays, suitably supported.

It is found to be advantageous to pick out the merchantable stocks by hand and at the same time break all the increase loose from the clump. The large bulbs are placed by hand in receptacles and returned to the shelves, or they may go directly into bags for shipment. The small bulbs, together with the old coats and dirt are left on the table, being pushed to one side by the cleaner until they have accumulated sufficiently, when they are either shoveled or pulled by hand into baskets or tubs, in which they are conveyed to a fanning mill. This machine, with a suitable arrangement of sieves and padding to prevent bruising removes the dirt and blows out the old coats, leaving the stock clean and ready to be sized preparatory to planting.

A grain-fanning mill is found to be almost indispensable for cleaning the small bulbs. The mill is padded with burlap and usually all sieves but one, which removes dirt, are dispensed with. By exercising care it is found that no particular injury is done by the mill to the smaller sizes of bulbs.

Every operation in the cleaning must be carefully watched, to prevent bruising the bulbs. Inexperienced or careless labor can do irreparable injury in a short time, even by such an operation as tossing bulbs into the containers instead of carefully placing them therein.

The cleaner should have a scoop (Pl. XIII, Fig. 1) close at hand, and the bulbs should be placed in this receptacle and not thrown into it. Such a vessel is much better than a box or pail, for bulbs do not have to be dropped into it, and when it is emptied its discharge of the bulbs into bags or onto the shelves again is much less likely to cause injury.

Piles of bulbs on the shelves or on the tables are generally handled with ordinary iron shovels. At times a homemade, flat-bottomed, wooden hand scoop is used, not essentially different from those sometimes used by grocers; but if care is exercised there need be no more injury from the use of a common iron shovel. For getting the bulbs

off the solid benches the shovel must have its handle shortened, and sometimes the edges are turned up a little and also the shank straightened out, so that it can be operated more advantageously in a smaller space. There is no need to injure bulbs with this tool.

The container scoops (Pl. XIII, Fig. 1) are homemade and constructed in various sizes for different purposes. Where the bulb house is equipped with solid benches close together, this is the only container that can be employed to advantage to load the benches. For this purpose large scoops holding half a bushel are used. Smaller scoops are made for pouring bulbs into pails or bags. The advantage of the scoop over a pail lies in the fact that in transferring bulbs to another receptacle they are not dropped so far from a scoop as from a pail or box.

A convenient table is 4 feet wide for large operations and of any desirable length (Pl. VIII, Fig. 2). It is made tight and smooth with a 1 to 1½ inch edge rail. Sections of this rail at suitable distances are detachable, to facilitate the removal of small bulbs or dirt from the table. The cleaner, when he has accumulated a pile of small bulbs on the table beside him, can remove a foot-long section of the edge rail and scrape them into a scoop, tub, or basket, to be taken away.

It is convenient to have one or two movable partitions (two are shown in Pl. VIII, Fig. 2), which can be moved along, as occasion requires, to accommodate and separate more than one variety on the table at one time. This is simply a board fitting loosely but so close that no bulbs go through between it and the edge rails on either side. Into each end is fitted a small piece of board at right angles, to hold it upright.

Occasionally it will be found that the general plan for cleaning outlined above can be advantageously modified; for varieties differ and stocks of the same variety will vary from one year to another, according to methods of culture, seasonal variation, and other causes. Should tulips for any reason be left undug, there is always a tendency to a multiplicity of small bulbs, which is also likely when a general lack of fertility obtains over a period of years. In such cases it may be advantageous to run the bulbs over an 8-centimeter screen before the large ones are picked over.

Cleaning bulbs is work that requires great dexterity and adaptability. Some laborers perfectly good at other jobs are often unable to do this work advantageously. Those not initiated into the work have a tendency to use one hand only or to take the bulbs up in one hand and break them with the other. Both hands must be used and for the most part independently. It is work that requires good finger strength and consequently can not usually be done satisfactorily by boys under 15 years of age.

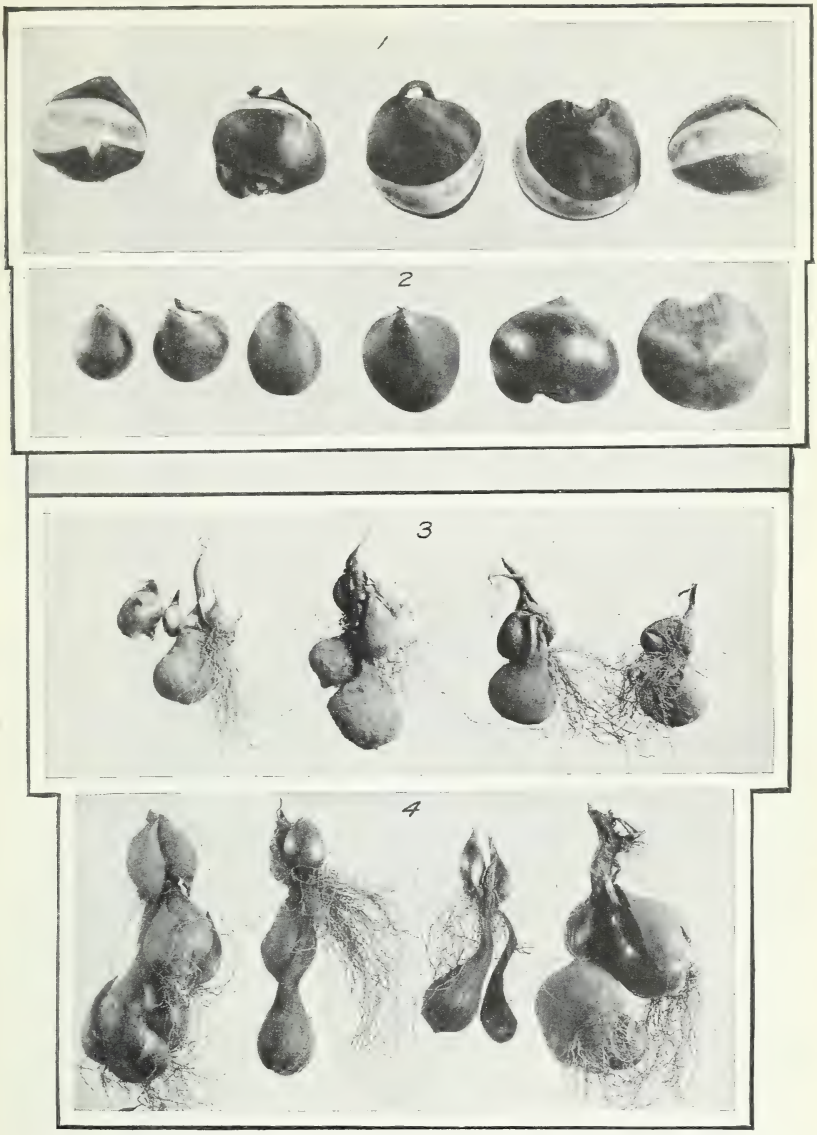
The most common method of work is for the man, with say a square foot of clear space directly in front of him, to pull down from the pile a small bunch of bulbs and spread them out in a single layer. He then picks up the clumps and breaks off the bases. This, also, usually loosens the small bulbs which drop on the table. Five or six bulbs are cleaned in this way without lifting the hands. When the hands are full, the bulbs are put in the scoop and the coarser débris on the floor. No attempt is made to get all the débris off, but only the roughest of it, which interferes too seriously with the operation of the fanning mill. The small bulbs or planting stock are left on the table, to be gathered up from time to time and cleaned in the fanning mill. The cleaning work is shown in Plate VIII, Figure 2.

Short cuts can be made, depending upon the condition of the bulbs. As an illustration, one year these experimental stocks in one variety had a large number of bulblets of 5 centimeters and under, which rounded up into 6 to 8 centimeter bulbs with no increase. When dry the roots and coats were so few as to be of no consequence. These bulbs and bulblets were put through the fanning mill, sized, and planted with no handwork. Handling in this way necessitated keeping these sizes separate on the shelves. Had they been mixed with mature stocks this method of handling could not have been used.

HANDLING THE CLEANED BULBS.

It is of the utmost importance that bulb handling be as simple as possible and that the number of handlings be reduced to a minimum. Consequently, when the marketable stocks have been picked out they should be sorted into first and second sizes at least and then, if possible, go directly into the containers in which they are to be marketed. The writer has recently found that it is feasible to transfer the marketable bulbs from the cleaning tables directly into the conventional paper sack holding 250 to 400 bulbs and set them away to cure in these open containers until two or three weeks later, when they are crated for shipment.

If for any reason it is not practicable to put the bulbs into the permanent packages direct from the cleaning tables, they must, of course, be returned to the shelves, where they can be piled deeper than before. After the cleaning has taken place, two decided changes should be made in their environment. They must not be subjected to strong light; indeed, the light should be much subdued and the ventilation in the bulb house decidedly reduced. Both of these conditions are necessary to preserve the coats and prevent too rapid desiccation. (Pl. I, Fig. 1.) On the other hand, the house must not be allowed to get stuffy, or molds will develop.



CARDINAL'S HAT, GRETCHEN, AND MACROSPHILA TULIP BULBS.

FIG. 1.—Mature bulbs of single early tulip Cardinal's Hat, showing horizontal split across the back when dug. This condition is prone to occur in this and some other varieties on new ground. FIG. 2.—Variation in the size of flowering bulbs in the same variety as shown in Figure 1. There is shown a variation of 6 to 13 centimeters. All of the bulbs flowered the current year. FIG. 3.—Droppers of Darwin tulip Gretchen. The clumps are shown as dug from 5-centimeter bulbs planted 35 to the row and dug at one year. FIG. 4.—Droppers in single late tulip Macrosphila left undug until the second year. It will be seen that there are in some cases two droppers to the same or different levels. Dropping occurred in both seasons.

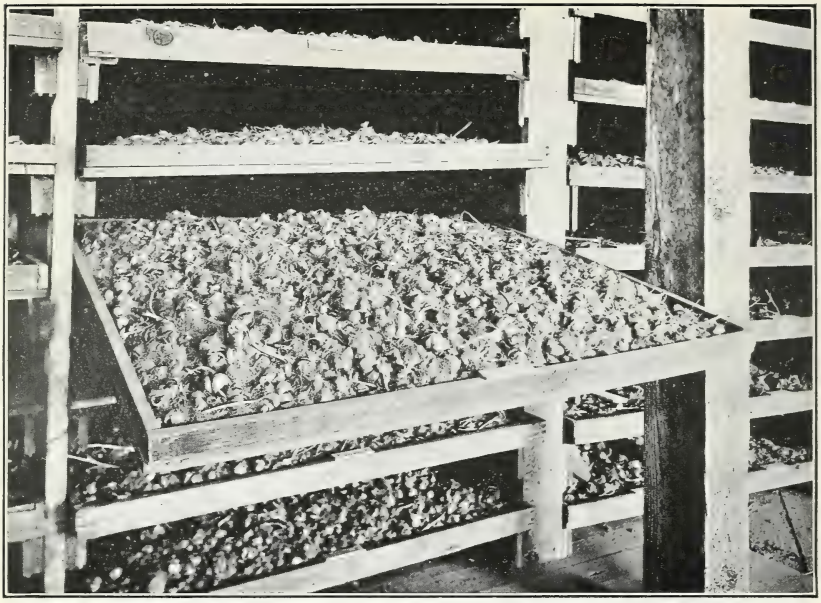


FIG. 1.—A TRAY OF BULBS IN PROCESS OF CURING PULLED OUT OF THE RACK FOR INSPECTION.

FIG. 2.—A TRAY OF MCKINLEY SINGLE EARLY TULIP BULBS CLEANED AND PARTLY WITHDRAWN FROM THE RACK FOR INSPECTION.

TULIP BULBS BEFORE AND AFTER CLEANING.

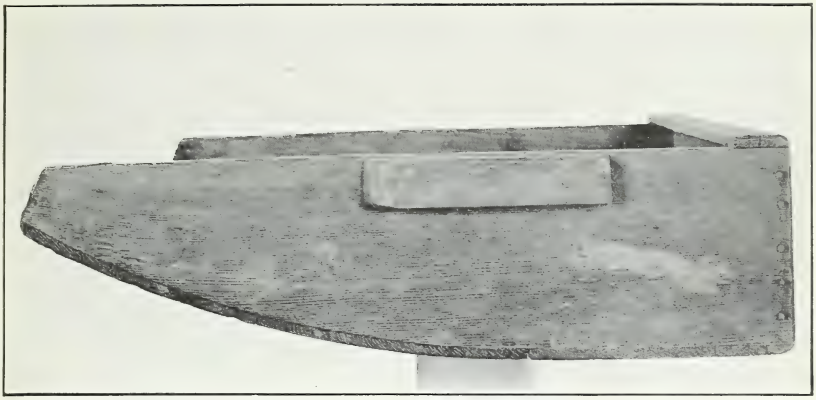


FIG. 1.—A SCOOP FOR HOLDING BULBS.

It is almost indispensable to have several of these around a bulb establishment to facilitate the transfer of bulbs from one place or container to another.

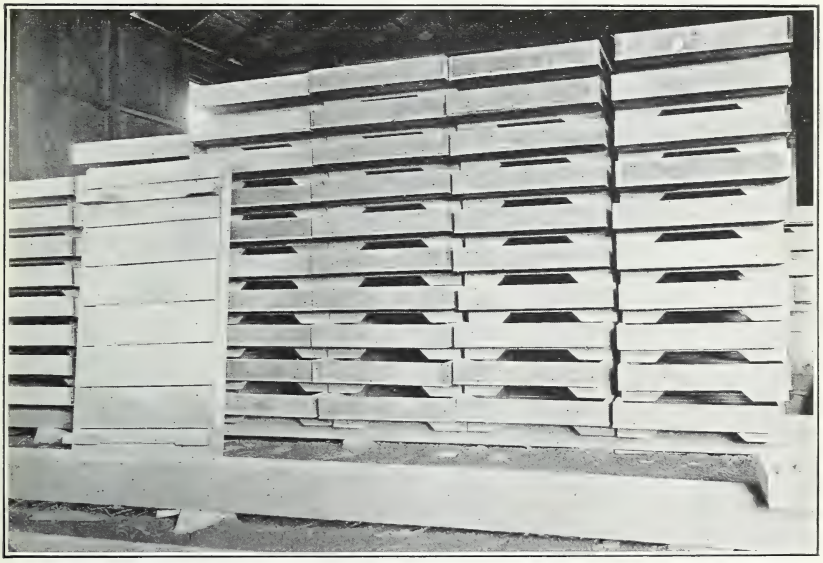


FIG. 2.—A FORM OF BULB TRAY DESIGNED AND USED BY C. W. WARD.

These trays are 3 by 9 feet in size and are made to stack without racks or other fixtures in the house.

FIG. 1.—TULIP BULBS PACKED IN PERFORATED PAPER SACKS HOLDING 250 OR MORE.

Packing material in the form of sawdust, buckwheat hulls, or other grain chaff may or may not be used between the bulbs.

FIG. 2.—SACKS OF BULBS PACKED TIGHTLY IN CRATES.

This shows an entire season's turn-off of the Department's experimental stocks of tulips from 1¼ acres.

PACKING TULIPS FOR SHIPMENT.

When proper control of the bulb house is not possible, it is a good plan to pile the bulbs higher on the shelves and cover them with buckwheat hulls or old burlap sacks.

The above relates to the stock which is to be marketed. The small bulbs which constitute the planting stocks are put through the fanning mill and then returned to the shelves, where they remain until required for planting. They should be handled with just as much care and in practically the same way as the bulbs which are to be marketed. On account of poor aeration it is not safe to pile the smaller sizes of bulbs as high on the shelves as the larger bulbs. They must be kept from molding and from too rapid drying out. In the climate of Bellingham, Wash., when digging is done in July and planting in August, difficulties of this nature are not serious.

PACKING TULIPS FOR SHIPMENT.

Many methods are employed in packing tulips for shipment, the main requisite being a well-aerated pack. For short shipments and small packages aeration need not be considered, but large quantities must be aerated lest they should heat.

The most satisfactory shipments are made in perforated paper sacks holding 250 to 400 bulbs, like those used with imported bulbs. These sacks are packed in slatted crates holding 15 to 20. Shipments may be made both with and without buckwheat or other chaff between the bulbs, and apparently with good success in either case. Often bulbs of the cheaper sorts from Holland placed loose in slatted crates arrive in good condition. The more expensive sorts are always packed with greater care.

Sacks for large shipments are not always readily obtainable in this country, especially in a strength of stock that is required. The Bureau of Plant Industry has used a square-bottomed sack of sterling leather paper having a bursting strength of about 55 pounds, but about 75 pounds is safer, and this is what is used by the foreign grower. Since there is some moisture present, it is important that the sack be well glued. The sacks for large shipments are about 9 by 19 inches, and when filled hold 250 to 400 bulbs. The top is folded, so that a tie once around each way with a stout cord holds. (Pl. XIV, Fig. 1.) At times, cloth sacks holding 1 peck have been used with satisfaction, but there is objection to cloth for the reason that the aeration is not so good as with the perforated paper sack.

The style of crate used by the Bureau of Plant Industry has varied from year to year and, of course, will vary until a bulb business develops in some locality where cooperation and teamwork will standardize operations and materials. The crates now employed are about two-thirds the capacity of the larger Dutch crates.

The crates should be constructed so that a definite number of sacks will fit snugly. (Pl. XIV, Fig. 2.)

IMPORTANCE OF CLOSELY SIZING MERCHANTABLE STOCK.

The value of bulbous stock is dependent in a very large measure upon its uniformity of performance under either forcing or bedding use. One of the most important factors governing this uniformity is the size of bulbs. It is consequently important that the merchantable stocks be closely sized, for the effectiveness of the planting depends upon having the plants alike, the flowers uniform, and the time of flowering the same.

SIZES.

Tulip bulbs are measured in a rather peculiar way, from the American viewpoint. We speak, for instance, of a 12-centimeter bulb, meaning presumably that the bulb measures 12 centimeters in circumference, but it seldom does, owing to its angularity. Although we speak of sizes in circumferences, it is after all diameter that is measured, because the size of a tulip bulb is the periphery of a circle whose diameter is equal to the greatest diameter of the bulb. The bulb caliper (Pl. X, Figs. 1 and 2) is a round hole. Bulbs which pass through an 11-centimeter orifice or screen and are caught by a 10-centimeter screen are called 10 to 11 centimeter bulbs, although the individuals may differ widely in actual quantity of material. This is probably as fair a method as any for measuring such irregular objects.

The sizers are usually so built that sizes varying 1 centimeter in circumference may be sieved out. It is then possible to recognize as many sizes as there are unit centimeters between the smallest and largest size of tulip bulb, or about 12 sizes. In practice, however, the commercial tulip is sorted into two or three sizes, usually referred to as first, second, and third grades or sizes, though the mechanical sizing of tulips has no element of grading in it. Grading is done by culling by hand all imperfect bulbs. Having picked out his commercial sizes, which are mostly above 10 centimeters, the grower resorts to a sizing of the remaining bulbs for his planting stock. It will be seen that the bulk of the Bureau of Plant Industry planting stock runs 8, 7, 5, and under 5 centimeters. The 5-centimeter size really extends from 5 to just below 7 centimeters.

It should be noted that a sizer in the form of a grating (Pl. XV, Fig. 2) will not give the same results as one having round openings for the bulbs to pass through (Pl. X, Fig. 3). In the one case the greatest diameter governs and in the other, the shortest.

WEIGHTS AND MEASURES.

With objects of such variable dimensions as tulip bulbs it is manifestly as impossible to arrive at absolute accuracy in connection with

weights, measures, and numbers as it is with potatoes or any other similar crop.

The data in Table 3, worked out in August, 1920, ten days to two weeks after the bulbs were cleaned, may be accepted as representative. Counts and measurements were made of the bulbs as they had dried out for that length of time on the shelves in a bulb house which was poorly controlled.

TABLE 3.—*Relation of weights and measures of tulip bulbs.*

[All bulbs flowered this year except those of Farncombe Sanders.]

Name of the variety.	Size of bulbs (centimeters).		Bulbs to a bushel.		Number of bulbs in a pound.	Remarks.
	Planted.	Dug.	Number.	Weight (pounds).		
Farncombe Sanders.	8+	11 to 15	770	54½	14⅛	About half of the bulbs were long necked.
Cardinal's Hat	8+	11 to 13	1,050	56½	18+	Bulbs rather undersized.
Clara Butt	8+	10 to 13	980	56	17½	
Crimson King	8+	9 to 12	1,295	56	23½	
Macrosphila	8+	10 to 12	1,148	56⅞	20+	Stock planted last autumn.
Do	8+	[a]9 to 13	1,855	56	33⅛	Stock undug last year.
Fairy Queen	8+	11 to 13	944	56	16⅝	

[a] Mostly 9 to 10 centimeters.

From Table 3 it will be seen that the weight of a bushel of bulbs is quite constant, and 56 pounds has been adopted as the weight of a bushel measure slightly rounded. So far as known, no standard weight of a bushel of tulip bulbs has been established. The number of mature bulbs in a bushel will manifestly vary greatly with the variety, as will the variety under different methods of handling and the crop of one season with that of another.

PREPARATION OF STOCKS FOR PLANTING.

Let us assume that the stocks are all cleaned and returned to the shelves. Some work must still be done on them before they are ready to plant. The method used in sizing the bulbs will depend upon the kind of machinery employed. Except where the operations are large and the equipment ample the work is likely to be done on a makeshift basis. But if any quantity of bulbs is to be sized, the grower can not well get along without about four nesting sieves. (Pl. X, Fig. 3.) This will allow of a separation into five sizes. For moderate quantities of bulbs the sieves can be operated by hand, but it is decidedly advantageous to construct a shaker, as shown in Plate XV, Figure 1. This holds the nest of sieves and may make a separation at one operation of about one-third of a bushel into five sizes.

When these separations have been made, each size is placed in a different container, labeled, and sent to the field in lots, each lot

representing a variety sized as they are to be planted. The containers for this work may be any suitable receptacles. It is the practice of the Bureau of Plant Industry to use lug boxes, tubs, and sacks, according to the quantity of each size planted. In commercial work, where the number of varieties is reduced to a minimum, this matter is very much simplified.

IMPLEMENTS OF TULIP-BULB PRODUCTION.

Ordinary farm tools suffice to put the land in condition for tulip culture. A plow, harrow, disk, rolling-disk packer pulverizer, and at times graders and ditchers are the implements employed.

The special tools are few in number and simple in construction. Usually they can not be bought ready made in this country, but must be homemade or made to order. Such tools, however, present no difficulties which any carpenter or blacksmith can not overcome.

Marker.—The marker (Pl. VI) is essentially a revolving drum, so constructed that it marks the center and margins of a 3-foot bed, together with rows 6 inches apart across the bed. It is a simple implement, having solid circular ends of wood 18 inches in diameter, these being held in place by slats set in the periphery 6 inches apart, for marking the rows. Another board wheel into which the cross slats are mortised is placed in the center of this roller marker for rigidity. Then by binding over the end and center wheels with a hoop, which may be one-fourth to one-half inch thick, the center and margins of the bed are marked with longitudinal lines. Through the center runs an axle, to which the operating handles are attached.

Screens.—Screens for removing the loose dirt at the time of digging are indispensable in any considerable operation in bulb culture. They are simply rectangular shallow boxes 14 by 22 inches in size and 4 inches deep with galvanized-wire bottoms. A mesh of one-fourth inch is the most serviceable for tulips. (See Pl. IX, Fig. 1.)

The ends of these trays are reinforced with an extra thickness of board. This gives greater rigidity and allows for the construction of a handhold without impairing the safety of the contents while the sieve is operated.

Besides these hand screens, which are used for small and moderate quantities of tulips, there are larger machines, usually spoken of as shakers. They are rectangular boxes mounted on a frame in such a way that the contents may be agitated vigorously to remove dirt. They handle about a bushel of bulbs. This machine, well illustrated in Plate IX, Figure 2, consists of a rectangular tray, like the small hand sieve, but the box is 2 feet 4 inches wide, 6 feet long, and 8 inches deep. It also has a $\frac{1}{4}$-inch wire-mesh bottom. About 15 inches from one end there is inserted a removable slide partition, and the wire bottom terminates at the slide. Over the opening back of the slide

FIG. 1.—CONVENTIONAL RAWHIDE NESTING SIEVES SHOWN IN USE.

Three sieves are shown nested on a carrier which may be vigorously shaken by hand. The use of three sieves gives four sizes, one below 5 centimeters in this case falling into the pit below and being removed through the sliding door.

FIG. 2.—SIZING BULBS BY ANOTHER METHOD ON AN ENTIRELY DIFFERENT PRINCIPLE.

By the apparatus shown in Figure 1 the longest diameter of the bulb governs, while in this the shortest diameter governs.

SIZING TULIPS.

SINGLE EARLY VARIETIES AND A DARWIN TULIP.

FIG. 1.—Yellow Prince. FIG. 2.—Sieraad van Flora, one of the robust Darwins. FIG. 3.—Thomas Moore.

is fitted a bottomless cloth tube (usually an old sack). By proper manipulation of this screen-bottomed box on its support, the contents can be "jerked" out of this opening, upon the removal of the slide partition, without touching the bulbs by hand. In this way the bulbs are mechanically and expeditiously transferred to the lug boxes with a minimum of labor.

A modification of this shaker is often employed. This consists essentially in dispensing with the frame and mounting the screen-bottomed shallow box on a piece of pipe between two supports, so that when empty it just tilts toward the operator, and the near end is supported by a short stick which holds it at a small angle with the horizontal. A bushel of bulbs is oscillated back and forth by rotating the box through a small arc on the pipe support. This is the form of machine generally used by Hollanders in this country.

Digging spades.—While there are no tools on the market adapted to bulb digging, it is possible to remodel tools to serve the purpose. (Pl. X, Fig. 4.) A boy's spade with the handle cut down to 16 inches makes a very serviceable tool. This is done by setting the D handle lower down, or by simply cutting off the handle at the proper length and attaching a crosspiece in the form of a T for a handhold. This makes a spade about 22 to 24 inches over all.

The main requirements for this tool are that the blade be flat and the handle as nearly straight as possible. This spade is never used to lift the soil, but simply to pull it toward the workman. To do this it is necessary to have the blade flat on account of the small space between the rows. Otherwise, there is greater danger of cutting the bulbs.

Planting boxes.—In the field at planting time it is necessary to have small, light, shallow boxes holding 4 to 6 quarts of bulbs. (Pl. VI, Fig. 2.) These are especially useful in planting the smaller sizes, as it is not profitable to strew them along the beds from the lug boxes as is done with the larger bulbs. With us, these are made of three-eighths and one-half inch light wood and are 12 by 12 inches and 3 inches deep, inside measurements. These should be well and smoothly made and light.

Scoops.—Scoops are essentially pouring vessels, but are also very useful on the tables at cleaning time to receive the bulbs as they are cleaned. They are made as shown in Plate XIII, Figure 1. They are useful in various sizes, from a peck to a half bushel.

Sizers.—The most common sizer (Pl. X, Fig. 3; Pl. XV, Fig. 1) used for moderate quantities of tulips is a circular, sievelike instrument, with a bottom of rawhide in which are cut holes of definite circumference. In some cases wire screens are used for this purpose, but the bulbs are much less likely to be bruised by rawhide.

Another tulip sizer is shown in Plate XV, Figure 2. This is essentially a chute or inclined plane made up of sections of parallel gratings,

over which the bulbs roll until they come to openings large enough to pass through.

In the Netherlands, various other forms of sizers are employed. The "Vlinder" is probably the most widely used machine. It is essentially an oscillating plane made up of sections of rawhide perforated in accordance with the conventional methods of sizing bulbs.

Another machine is a hexagonal revolving drum made up of sections, each of which separates one size of bulb. It is similar in principle to the common gravel screen used in this country.

Calipers.—These instruments are used to measure individual bulbs. One form consists of a thin piece of veneered wood in which are bored holes varying usually from 3 to 23 centimeters in circumference. (Pl. X, Fig. 1.) A more convenient form is put up in five veneered strips about 3½ by 12 inches, superimposed upon each other and fastened together so as to open like a fan. (Pl. X, Fig. 2.)

Blowers.—The blower used in this work is a grain fanning mill, with the wind, sieves, and padding so adjusted as to accommodate the handling of planting stock of bulbs. This winnows out the dry scales and light material from a mass of small bulbs. (See p. 22.)

Lug boxes.—The lug boxes used need not be essentially different from the fruit lug box, and they are used in the same way in hauling bulbs from the field at harvest time and back to the field again at planting time. These should, of course, be as light as consistent with the necessary strength.

Spud.—A good spud is an essential tool for roguing, i. e., taking out stray bulbs from the beds at blossoming time, when they can be most easily detected. It can be made with a strong fork handle 30 inches long, attached to a steel blade 2 inches wide and 8 inches long with a short curved shank inserted into the handle through an ordinary ferrule. This has been found the most serviceable tool for removing a bulb from a thick planting with as little disturbance as possible of neighboring bulbs.

Trowel.—The common garden trowel used in this country is poorly adapted for use among bulbs. A tool of this kind with a flat blade is much more serviceable. In very light soil such a tool can be used for digging.

THE DUTY OF LABOR.

In any consideration of the duty of labor the climatic factor plays a very important part. Tulip-bulb production can be conducted best in a region of relatively low, uniform average temperatures, and this is where labor is most efficient. If the digging and planting of the bulbs must be done in very hot weather, labor efficiency is very much reduced. On Puget Sound the weather conditions are ideal.

In summer, when the heavy work occurs, the temperatures are seldom up to 80° F., a condition most favorable to the efficiency of labor.

The following account of the cost of growing an acre of tulips must be considered excessive from a commercial point of view. It is to be looked upon as the cost of experimental culture, but it is the only available record in this country. It will serve as a basis for the estimate of cost until such time as it may be possible to secure cost accounting from commercial growers.

The cost of the different operations is given in some detail, the better to enable the grower to form his own judgment.

Digging.—The best information as to efficiency in bulb digging can be gleaned from an account of actual performance on the Whatcom silt loam, which is a heavy soil near Bellingham, Wash. In the summer of 1920 the short acre of tulips was dug between June 22 and July 14. During the greater part of the time that digging was in progress the crew consisted of one experienced man, four boys with one year's experience, and three boys without previous experience. Considering all the labor on the same basis, it took a total of 61 days to dig the acre. Putting the matter another way, the workers dug in a day an average of three beds 42 feet long. This is 126 feet of a 3-foot bed in 8 hours. Under the conditions of heavy soil and the large element of inexperience in the labor, this may be considered a very fair average for an 8-hour day for a month's digging. It should be noted, however, that at the end of the month some of the boys were able to accomplish about twice their average at the beginning. The average at the beginning was only two beds a day, while toward the last each boy was able to dig $3\frac{1}{2}$ to 4 beds in a day.

Cleaning tulips.—It has never been possible at Bellingham, Wash., to get an estimate of cleaning continuously an acre of tulip bulbs. At no time has it been possible to put a definite number of men on the job and keep them on until they were through. At various times, however, the boys have been timed on representative squares of shelving.

When the bulbs are normal and the trays are well rounded an active boy will clean four trays, but when not so full, as described under "Shelf room required," he will clean five trays, or 80 square feet of tray space, in a day of eight hours. This means that the large bulbs are picked out and the planting stock blown by a fanning mill as described elsewhere. Extending this data to the acre unit, it means that a man or active boy will clean the product of an acre of tulips in 30 to 35 days.

Marketing.—There is no use in attempting to get at the labor cost of marketing an acre of tulips, for the reason that this depends upon varying conditions that would be hard to duplicate. The Depart-

ment of Agriculture has usually shipped a minimum carload in bulk. With containers ready and tulips cleaned on the shelves, four men one year packed 300,000 tulips in a little over a day. But this was what might be termed "bulk shipment." The filling of small orders would be slower, and more time would be consumed in proportion to the number of the orders. It is believed that the cost of marketing tulips will not differ very much from that of marketing gladiolus.

Planting tulips.—Commonly the planting crew consists of two men and four boys. A crew as large as this is used because inexperienced boys are not able to keep bulbs set ahead of the two good men mucking and raking. Usually with a little experience and selection boys may be found, two of whom can do the work. It is considered that a good planting crew consists of two men and two adaptable, experienced boys. Such a crew as this has put in 25 beds a day. One crew of this size put in an acre of tulips on two occasions in a little less than eight days. The same performance was duplicated last year. Mr. Houser, who managed the crew both years, is of the opinion that such a crew after two weeks' experience should be able to put in an acre in seven days.

Cultivation.—Under cultivation is included all work done on the ground in the way of raking, fall and spring cultivating, and hand weeding. It is interesting to note that one man spent 1½ days in hand weeding 1 acre for the 1920 crop. The total time on this work was 18 man-boy days.

Marking and opening the beds.—Boys did the work of marking and opening the beds on the acre in 10½ days.

Sizing and storing.—The time required for sizing and storing tulip bulbs in the experiments at Bellingham, Wash., is much in excess of that necessary for commercial operations, on account of the multiplicity of varieties. One man occupied on this and other miscellaneous duties worked 16 days.

Roguing.—It took one man 4½ days to rogue the acre of tulips in 1920.

Cutting flowers.—To remove the flowers from the beds and compost them took the labor of one man for 6 days.

TABLE 4.—*Labor of growing an experimental acre of tulip bulbs.*

Operation.	Labor summary: Man-boy labor (days).	Operation.	Labor summary: Man-boy labor (days).
Digging	61	Sizing and storing	16
Cleaning	35	Roguing	4½
Planting	48	Cutting flowers	6
Cultivation and weeding	18		
Marking and opening beds	10½	Total	199

Labor summary.—The labor of growing an acre of tulip bulbs is summarized in Table 4. To arrive at the total cost the interest on the investment must be added and also the cost of preparing the ground, which will not differ materially from the preparation for potatoes or any other similar crop.

SOILS.

A soil which will not bake is suitable for the production of tulip bulbs. If it is light and friable, it will be much more easily handled. If it is lean and sandy, the cost of fertilizer will be heavier, but this will probably be compensated by a much lower charge than is required for handling a heavy loam.

FERTILITY OF PARAMOUNT IMPORTANCE.

That tulip bulbs of good quality can not be produced on infertile soil should be recognized as axiomatic. The numerous failures experienced by the householder who has endeavored to continue his stocks of bulbs year after year are due to a lack of proper soil fertility more than to any other cause. Tulip stocks of practically all varieties "go all to pieces," so to speak, when grown year after year on poor soil.

EXCESSIVE FERTILITY.

While tulips, like most bulbous stocks, require heavy fertility, it is possible to apply too much raw manure for them to give best results. An application of manure too near the time of planting, even though it be not excessive in quantity, is also likely to cause injury. A heavy application of manure with the removal of some other crop previous to planting the bulbs furnishes the ideal condition for tulips.

Excessive stimulation often manifests itself in the tulip by a large approximately horizontal gash in the coat across the back of the bulb, as well as by excessive size. (Pl. XI, Fig. 1.) The bulb seems to expand at too great a rate for the coat, which is ruptured and slightly wrinkled, as well as somewhat thickened over the remainder of the bulb. This is very different from the irregular splitting of the coats due to too great exposure. Here the split has already occurred before the time of digging, and the white, living scales beneath are already somewhat discolored by contact with the soil.

Such conditions are likely to occur to some extent when tulips are grown on new, fertile soil, even though it be not heavily fertilized, but in the absence of added manures it is not likely to be serious.

Some varieties are much more susceptible to injury from this cause than others. Cardinal's Hat is very susceptible. In 1919 the stocks of this tulip at Bellingham, Wash., had not over 5 per cent of

perfect bulb coats in the merchantable sizes when dug. The planting was on newly cleared cut-over Whatcom silt loam which had received an application of 12 loads to the acre of half-rotted stable manure in May previous to planting in August and one crop of rye turned under. The size of the bulbs under these conditions was very much larger than normal, measuring fully 13 centimeters as against 9 or 10 centimeters under low fertility and 10 to 11 centimeters for the optimum.

THE SOURCE OF THE FERTILITY.

One thing above all others should be impressed upon the American tulip grower, i. e., that cow dung is not the only source of fertility that can safely be used; indeed, in fertile soil with good cover crops no animal manure may be necessary.

Stable manure from which the "fire" has gone seems to be as good as any fertilizer. Sheep manure gives good results, and bone meal can not be surpassed, but it is too expensive for liberal use.

The nature of the soil will have a great deal to do with the kind of fertility demanded. On our heavy silt loams humus is needed to give porosity and tilth and opportunity for percolation of water, which these soils do not naturally have.

To put the matter tersely, the crop is no more exacting in the nature and origin of its required fertility than any other farm crop. It demands plenty of it, but is not particular as to its source, which means, as in other farming operations, that the grower will resort to whatever source of fertility is available to him. Commercial fertilizers can best be supplemented by cover crops and other means of adding humus.

DISPOSAL OF CROP RESIDUES.

As with many other horticultural crops, care should be exercised in the handling of the refuse from tulip-bulb production. This should not be burned or otherwise wasted, but should be handled so as to avoid its use on land which is to grow tulips or other bulbs, as an added precaution against the spread and accumulation of the spores of fungi which cause diseases. This is a very important matter and should not be overlooked.

This débris, made up largely of stems and leaves hoed off the beds at digging time, flowers cut off before the petals drop, old coats, and imperfect, rotted, and undersized bulblets, cleaned out of the stock during the time it is in the bulb house, should be composted and thoroughly rotted before being used on any ground; otherwise the bulbs will come up as weeds in other crops and be a source of annoyance and loss indefinitely. There are few weeds more persistent in cultivated fields than tulips which have been left undug or plowed in with unrotted compost.

DRAINAGE.

Whether the producer of tulip bulbs will be obliged to give serious thought to drainage will depend entirely upon his location. Even with the heavy precipitation of the Puget Sound region, level culture can be practiced on all the Lynden sandy loams except where they lie low and their water table is naturally high. On the Whatcom silt loams, however, the case is very different. Here careful ditching is required. Although the present location of the Bureau of Plant Industry plats is rolling and in the main contains sufficient fall, it is found necessary to maintain ditches down to the clay subsoil along the sides of each plat. Ditches have been dug on both sides of the roadways, and roadways around each two plats have a ditch between. This system seems to be necessary even though the plats run across a well-drained slope, i. e., when the drainage is good in the direction of the length of the bulb beds. Were it not for these ditches to intercept and carry off the drainage waters, the lower plats, even on hillsides no longer than the width of two plats (100 feet), would be too wet in the winter and during the growing season until May.

In shaping up the ground preparatory to planting, care is also exercised to contour the plats so as to get a gradual fall from the centers to the ditch on either side. The greater part of this is accomplished by plowing toward the center of the bed.

Even with beds only 40 to 50 feet long and the plats bedded up in the center, it is found that the conditions for growth on the ends of the beds are far from perfect for two reasons: (1) There is an accumulation of moisture to a detrimental degree in the first 4 to 6 feet along the ends of the beds, although the drainage slope is not over 25 feet in length; (2) owing to the building up of the center of the bed on soils which are so shallow, the ends of the beds are too close to the subsoil and have too much refractory clay in their make-up to let go of the surplus moisture as rapidly as desirable. The result is that the soil at the ends of the beds is likely to be hard and difficult to dig and the crop commonly much poorer than in the center. In extreme cases the bulbs so located rot, and nothing but old coats is to be found at digging time.

It will be readily appreciated that the contouring and ditch maintenance are expenses which are, of course, not necessary on well-drained lands.

WHERE TULIPS MAY BE GROWN.

That tulips are an exacting crop, as commonly supposed, must be most emphatically denied. There are certain requirements for their best culture, it is true, but these requirements can be satisfied over a comparatively large extent of territory.

Wherever soils are suitable, the Puget Sound territory is admirably adapted, as, indeed, is the whole Pacific coast from northwestern

California northward. Successes have been had in Michigan. Good bulbs have been grown on a small scale in Virginia, New York, Vermont, and Ohio. One success is recorded in southwestern Missouri, although confessedly under difficulty and only with Darwins and late tulips. Many more illustrations might be cited, but the above are sufficient to prove the contention that the crop is quite adaptable.

The main requisites are, first of all, a soil that does not bake, plenty of moisture, good drainage, and a not too rapid transition from winter to summer.

ENEMIES OF TULIPS.

If the tulip grower observes the rules of ordinary sanitation and good culture and rotates his crops so as not to get back on the same ground with tulips oftener than once in three years he seldom need worry about diseases. The tulip is remarkably free from pests. The popular notion that mysterious scourges come along and wipe out the crop is fallacious. Even a bulb so badly injured that it can not make root is often not lost. There is frequently a good, uninjured bud which will commonly round off into a perfectly healthy but small bulb which can be grown so as to give a normal progeny again. Often bulbs have been seen so injured by molds or poor drainage in winter and early spring that they died down four weeks before their time but left a perfectly healthy bulblet, although only a tenth of the size of the original.

The most serious enemy of the tulip bulb is the bulb house. Here all sorts of abuses are practiced which may lead to disaster, but the rots and the molds of the bulb house are no more diseases of the tulip than the same rots and molds are diseases of bread and pastry in the kitchen pantry. Of course, if the moisture conditions are not under proper control, bulbs in piles will rot, but so will wheat and corn, and it may be said that a properly cured tulip bulb with its coat on is about as effectively protected from fungi, either saprophytic or parasitic, as a grain berry. If the coats are abraded and the bulbs bruised, of course, the ordinary black and blue molds will find ingress and do great injury, but this is also true of potatoes.

Second to the "bulb-house pest" should be mentioned the fire disease, caused by the mold Botrytis. (Pl. VII, Fig. 2.) This is really the only disease of consequence which has affected tulips in this country. This saprophytic mold under certain favorable conditions is capable of becoming a real parasite, attacking and destroying living tissues.

When this disease appears in the bulb fields, little can be done to check its progress. It is said that the Hollander drives stakes around a focus of infestation and stretches muslin to prevent the spores being spread by the wind to healthy foliage, but it has never been thought that such a remedy was practicable in any attack observed by the

writer. In certain classes of infestation, wherein scattering leaves through the planting are "fired," it is advisable to go through and clip with shears the diseased portions and carry them out of the field.

Weeds allowed to grow to such an extent that good aeration is wanting contribute to the development of the fungus. Some fire has occurred in these experiments even on virgin soil when tulips have been left in for two years, although properly handled stocks close by were so clean that no fire could be detected.

To sum up, clean culture, safe rotation, sanitation in matters relating to the residues of the crop, annual lifting, care that the planting stock be not bruised, or allowed to become moldy or to be skinned in the bulb house are the preventive measures which will render diseases of the tulip negligible.

We may possibly consider as an exception to the above statements the mosaic disease of tulips known as "breaking." Investigations of this disease are now in progress, and it will be well to refrain from positive statements on the subject until authoritative information is obtained. A provisional discussion of this subject, however, will be of value in this place, giving the results of the observations and opinions of the writer and his horticultural associates.

The "broken" tulips are sold as a distinct race by the florist. They are listed as Rembrandts when derived from the Darwin section (Pl. XVI, Fig. 2, and Pl. XVII) and as "broken" tulips in other sections of the tulip lists. They are distinguished by the peculiar variegated or mosaic patterns of the floral coloration. These same patterns extend into the leaves and other portions of the plants, where the contrast of coloration, however, is less spectacular than in the flower, because the breaking in the leaves consists in simply an unequal distribution of the green coloring matter which results in a delicate and often only indistinct pattern of varying densities of green. In the flowers, however, especially when the ground color or the color of the tissues between the epidermal layer is yellow and that of the epidermis some brilliant shade, the pattern becomes striking and often very beautiful. There is an exact counterpart of this in the flower of the ornamental tobacco affected with the mosaic disease, which has been extensively studied by Allard and others.

The effect of the disease on tulips is precisely similar to the effect of the mosaic on tobacco. There is a decided dwarfing of the plant, a reduction of its powers of reproduction, and a general weakening of its constitution. The "broken" tulips, therefore, are less satisfactory to grow, especially if one is producing bulbs for sale, than the self-colored forms. In short, the mosaic or broken plant is weak and requires greater care and effort in the production of marketable stock from it. The breaking in tulips is again analogous to mosaic in that seedling stocks of broken strains are free from the disease.

At Bellingham, Wash., broken tulips have not been grown, and the stocks, many of which have been grown there for 15 years, numbering between 250 and 300 varieties, have not broken.

Any self-colored tulip (and all tulips grown from seed are self-colored) may become broken. The statement is sometimes made that the single early tulips do not break, but this is true in the florist's sense only. These break just as truly as the others, but they give in the breaking no spectacular patterns such as are found in other groups; on the contrary, the brilliancy of their floral coloration as well as their general vigor is reduced. Consequently, the broken plants in this group are rogued out of the stock.

The cause of breaking in tulips has not been demonstrated, neither has it been investigated until recently with the idea of its disease origin in mind. Nor for that matter has the real cause of mosaic diseases in other plants been demonstrated, although extensively studied. The essentials of communicability, effect on the host, carriers, and preventive measures are well worked out, however. As in tobacco, it is probable that here again the aphis is the main carrier of the disease. Fortunately the aphids have never been numerous in the bulb fields at Bellingham, Wash.

With this information before him the bulb grower should consider carefully before he attempts to introduce broken stocks into his plantings. It is known that the disease is communicable to self-colored stocks. There is, consequently, grave danger of his self-colored stocks becoming ruined if broken stocks are introduced, for when once broken they can be sold only as mixed tulips. The production of bulbs of these mosaic varieties should not be attempted except at safe distances from the regular self-colored stocks.

A peculiar trouble sometimes occurs in tulip bulbs when grown under adverse conditions which has caused growers concern because interpreted to be a disease. It manifests itself in the form of an imperfectly filled bulb coat. The base of the bulb may be quite normal and well filled but reduced in size, but the tip may be empty and wrinkled, as is well brought out in Plate VII, Figure 1. This condition has been observed in many varieties on the Pacific coast when planted shallow and late on very light soil that dried out too quickly in the spring.

WHY SOME VARIETIES ARE CHEAPER THAN OTHERS.

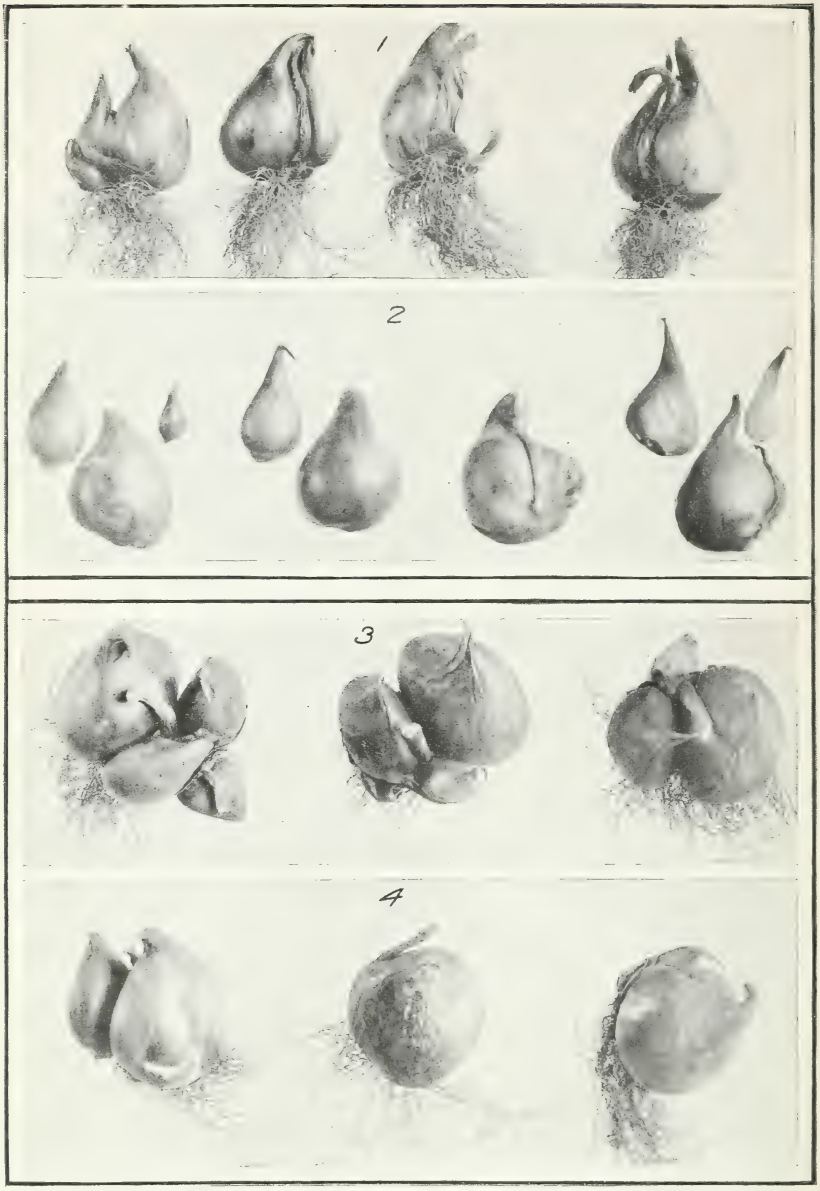
It is not necessary to discuss values in novelties or new varieties of which only limited stocks are available. Here the law of supply and demand and a desire for the new govern, as in any other commodity.

Leaving aside entirely the facts of actual merit, popularity, and consequent general demand, there are some varieties which can

FIG. 1.—A DARWIN TULIP PLANTING IN EARLY SEASON BEFORE THE FLOWER STEMS ARE SHOWING.

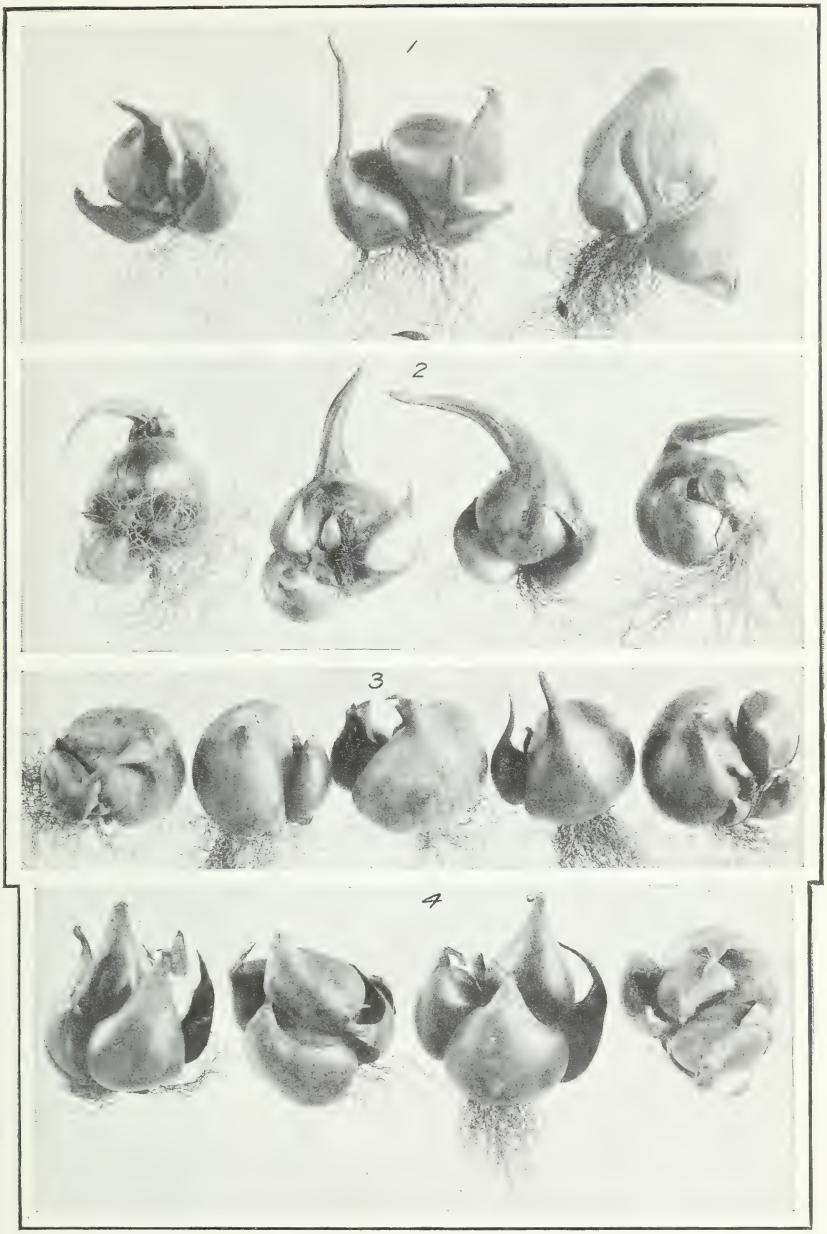
FIG. 2.—A PORTION OF THE FIELD SHOWN IN FIGURE 1 WHEN THE BULBS ARE IN FLOWER.

DARWIN TULIPS.



PROSERPINE AND KEIZERKROON TULIP BULBS.

FIG. 1.—Four clumps of Proserpine dug from 8 to 9 centimeter bulbs set 14 to the row. All flowered, but all did not propagate. FIG. 2.—The same bulbs shown in Figure 1, cleaned and separated. The variety reproduces poorly, which is the main reason for its comparatively high price. FIG. 3.—Reproduction in Keizerkroon from 10 to 12 centimeter bulbs planted 14 to the row. The bulbs were imported in the autumn of 1918 and used for bedding. They were dug as soon as the flowers had faded, heeled in to ripen, and were dug again early in June, 1919. The results are for the 1920 crop when the bulbs had become normal, but probably had not reproduced as well as they would have done had they ripened properly the previous year. FIG. 4.—Reproduction in Keizerkroon 8-centimeter normal bulbs which have been in the country 10 years. This popular variety is not prolific of increase.



REPRODUCTION IN CALLIOPE, FAIRY QUEEN, AND FULGENS TULIP BULBS.

FIG. 1.—Reproduction in Darwin tulip Calliope. There were planted 8 to 9 centimeter bulbs 14 to the row, which have grown to 11 to 12 centimeters, flowered, and produced an increase of two 10, three 7, and two 5 centimeter bulbs. FIG. 2.—Reproduction of the same variety as Figure 1, but 7-centimeter bulbs were planted 21 to the row. They have grown to 11 to 13 centimeters, with an increase of one or two 7-centimeter flat bulbs each. FIG. 3.—Reproduction in Cottage tulip Fairy Queen. There were planted 8 to 9 centimeter bulbs 14 to the row. This is a good tulip, but not as good a reproducer as some. FIG. 4.—Reproduction in Cottage tulip Fulgens, showing a wonderful increase in 8 to 9 centimeter bulbs set 14 to the row. The four bulbs have yielded three 11, three 10, and two 9 centimeter flowering bulbs, besides one 9, two 8, five 7, three 5, and two 4 centimeter bulbs for growing on.

FIG. 1.—A VERY SATISFACTORY REPRODUCTION.

The bulbs planted were 10 to 12 centimeters in circumference and set 11 to the row.

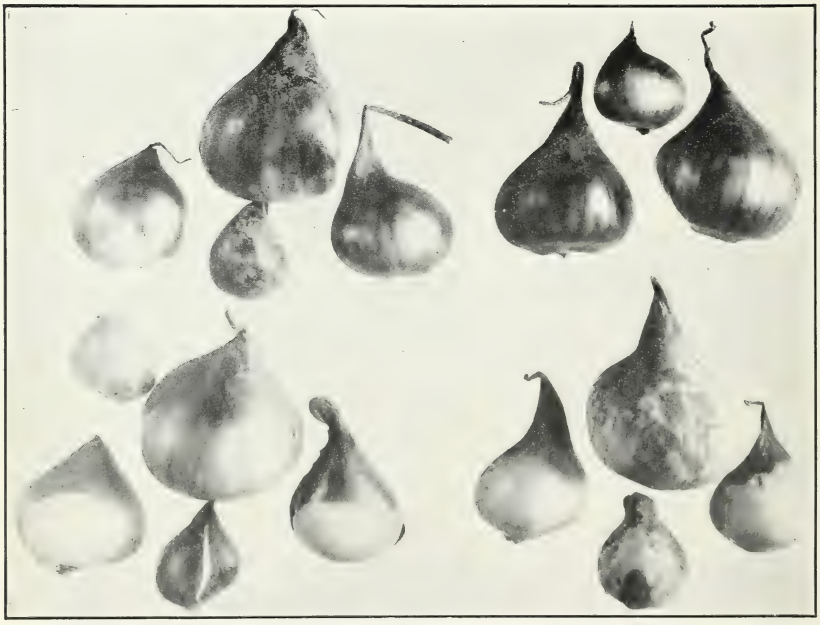


FIG. 2.—THE CLUMPS SHOWN IN FIGURE 1 CLEANED AND SEPARATED.

The actual performance, giving size and number of bulbs in each clump, is as follows: Upper left—one 14, one 10, one 9, one 7 centimeters; upper right—one 13, one 11, one 7 centimeters; lower left—one 14, two 10, two 7 centimeters; lower right—one 14, two 9, one 8 centimeters. Besides the mother bulbs, there are one or two in each clump that will flower next year.

PRIDE OF HAARLEM DARWIN TULIP BULBS.

never become cheap, because their production cost is relatively high. A comparison of the varieties in Plates XVIII and XIX, and an examination of the following performance tables (Tables 5, 6, and 7) will give valuable information on this point. It will be seen that between some varieties there is a difference in yield of 75 per cent or more. This is due to no accident or fault of location, but to the inherent characteristics of varieties. One is asked why Proserpine should be so expensive when it is an old, established variety. A glance at Plate XVIII, Figures 1 and 2, and its performance record will show that it is a poor reproducer and consequently the bulbs can never be cheap. Compare this with Artus (Pl. IV, Figs. 1 and 2) and Rosalind (Pl. IV, Figs. 3 and 4). In the autumn of 1919 these three varieties were planted at Bellingham, Wash., liberally, 14 to the row, mostly 8-centimeter round bulbs, but those of Proserpine averaged larger than the other two. Proserpine blossomed and made first-size bulbs with an increase of one or two, ranging from 4 to 9 centimeters each, while Rosalind also produced a first-size bulb for next year but gave three to six increase, ranging from flowering size downward.

The character of the reproduction is also a very potent factor of the cost. Some varieties produce a moderate number of large-sized bulbs as increase and others a large number of small ones. (Compare Pl. XX with Pl. V, Figs. 3 and 4.)

The popular Keizerkroon (Pl. XVIII, Figs. 3 and 4) is not by any means the easiest to grow and can never become cheap, like Artus for example.

PERFORMANCE RECORDS.

The number of bulbs sold from a given area of ground in any one year is not necessarily a measure of the grower's success in bulb culture. Many factors and conditions are to be considered, among which are the sizes planted, the sizes marketed, and the nature and quantity of the increase. The factor which should be studied most closely is the nature of the increase, commonly termed "propagation." (Compare Pl. III with Pls. IV and V and Pl. XVIII with Pls. XIX and XX.) After the merchantable stocks have been removed, there must be enough left of such sizes as will insure a similar product the following year to produce unqualified success.

In Tables 5 to 7 the results of many measurements of many varieties, made in many ways, are given in sufficient detail to enable the grower to judge of the success of the experimental production here outlined.

PROPAGATION BY ROWS.

A satisfactory unit of measurement in tulip-bulb production is not so easy to get as might be thought. One unit, and possibly as good a one as any, is a row across the 3-foot bed. Since this row is stand-

ard throughout the planting, a record of performance of bulbs in it is a record of the variety. The unit of measurement in Table 5 in each entry is the row whose length is the width of the bulb bed, or 3 feet, planted, but owing to the growth extending over into the paths the row may be considered 39 inches, and therefore comparable with the foreign beds, which are 1 meter wide.

To arrive at the propagation from the table, a calculation is necessary. The number of bulbs planted must be subtracted from the largest sizes specified in the yield columns; the remaining bulbs represent the "propagation" in sizes. In practice, this is strictly true, but from the standpoint of absolute accuracy in some cases there may be a slight error, for the reason that some of the increase may have grown to larger size than the bulbs planted.

The record is from plantings made in the autumn of 1919. The stocks planted were uniformly good.

Table 5 is largely self-explanatory. After the name of the variety is a column giving the size of the bulbs planted. The next column shows the number of bulbs planted to the row. Then follows a series of 12 vertical columns headed by figures showing in centimeters the circumference of the bulbs produced. In the horizontal spaces opposite each variety are shown the number of bulbs of each size dug from the unit row in July, 1920. The readings and calibrations were made in the field at digging time in July.

The stocks for which readings are given have been grown in the plats of the Bureau of Plant Industry continuously for the past 10 years or more, except Gretchen, which was imported in 1917.

TABLE 5.—*Propagation of tulip bulbs by rows in the Puget Sound region in 1920.*

Name of variety.	Bulbs planted.		Number of bulbs dug of each size (centimeters).											
	Size (centimeters).	Number to row.	14	13	12	11	10	9	8	7	6	5	4	3
Allard Pierson	8	14	2	2	....	7	3	....	13	8	4	8	....	7
Artus	[a]8	14	....	....	4	6	6	4	5	6	6	4	7	7
Do	7	21	....	....	....	7	5	15	....	6	....	10	5	6
Do	7	21	....	....	....	5	8	5	2	7	8	4	4	....
Do	5	35	....	....	....	....	6	9	5	12	13	7	6	9
Do	5	35	....	....	....	....	9	9	20	1	7	8	....	12
Aximensis	7	21	....	....	....	9	5	6	....	....	14	16	15	8
Do	8	14	....	....	2	2	8	11	....	11	13	12	7	....
Belle Alliance	8	14	....	....	6	7	....	1	....	....	....	3	....	....
Cardinal's Hat	[b]8	14	1	4	5	6	4	3	5	5	6	7	9	9
Do	7	21	....	....	....	6	5	8	3	....	5	5	....	11
Do	7	21	....	....	....	6	8	5	6	1	8	10	7	....
Do	7	21	....	....	....	6	7	6	9	1	4	3	7	3
Do	5	35	....	....	....	....	....	26	5	17	....	10	10	9
Do	5	35	....	....	....	....	....	15	4	16	9	7	6	....
Do	5	35	....	....	....	....	....	17	15	10	7	5	....	5
Chrysolora	8	14	....	....	....	10	....	3	1	....	....	1	....	....
Clara Butt	8	14	....	....	10	4	....	....	5	5	....	10	12	5
Do	8	14	....	1	8	4	1	....	8	14	....	6	6	....
Do	7	21	....	....	4	11	4	2	....	11	5	8	12	....

[a] An average in round numbers of 5 readings. [b] An average in round numbers of 10 readings.

TABLE 5.—*Propagation of tulip bulbs by rows in the Puget Sound region in 1920*—Contd.

Name of variety.	Bulbs planted.		Number of bulbs dug of each size (centimeters).											
	Size (centimeters).	Number to row.	14	13	12	11	10	9	8	7	6	5	4	3
Clara Butt	7	21	....	....	....	12	9	....	....	2	9	9	24	10
Do	7	21	....	....	....	11	....	9	6	13	....	10	10	15
Do	5	35	....	....	....	3	11	....	15	2	12	1	10	4
Do	5	35	....	....	....	1	14	10	10	3	....	8	6	10
Couleur Cardinal	8	14	....	....	7	....	7	1	....	3	2	....	3	....
Do	8	14	....	....	4	4	6	....	1	....	....	....	....	3
Do	7	21	....	....	....	6	7	5	....	....	....	2	....	....
Couleur Cramoisi	8	14	....	....	1	9	4	1	3	....	2	1	....	....
Do	8	14	....	....	4	6	2	....	2	....	3	....	2	....
Do	7	21	....	....	....	10	2	....	6	3	6	....	....	2
Do	7	21	....	....	2	3	....	10	6	5	5	....	....	....
Crimson King	8	14	....	....	....	6	4	3	6	6	....	....	4	....
Do	7	21	....	....	....	....	13	4	....	1	6	....	1	....
Do	7	21	....	....	2	....	8	7	3	....	2	....	....	....
Do	5	35	....	....	....	....	....	....	....	9	8	8	6	....
Dora	8	14	4	3	4	....	....	....	16	7	6	4	13	7
Do	5	35	....	....	....	6	10	8	10	1	....	....	....	5
Duchess de Parma	8	14	....	....	4	8	....	2	....	....	....	....	2	2
Do	5	35	....	....	....	5	6	7	9	....	3	4	11	3
Europe	8	14	....	....	8	....	4	2	....	1	....	3	....	....
Do	5	35	....	....	....	3	....	12	7	6	4	2	....	....
Do	7	21	....	....	4	7	....	10	1	4	5	....	3	....
Farncombe Sanders	8	14	2	5	....	5	....	6	3	6	....	4	....	3
Do	7	21	....	....	1	7	12	....	3	4	....	7	11	3
Do	5	35	....	....	....	4	10	12	7	3	8	....	9	4
Faust	7	21	....	....	....	7	6	....	8	....	....	8	6	....
Fra Angelico	8	14	....	9	2	2	4	1	....	7	7	4	5	....
Fulgens	8	14	2	....	6	6	....	....	16	17	11	5	9	4
Do	7	21	....	....	7	7	7	2	12	1	12	13	10	9
Gretchen	8	14	....	....	5	5	3	6	1	1	13	7	....	....
Do	5	35	....	....	....	1	....	9	17	7	7	26	27	8
Do	7	21	....	....	3	7	....	5	11	2	11	10	8	15
Isabella	8	14	....	....	1	7	4	2	9	10	6	3	6	....
Do	7	21	....	....	....	10	9	3	10	9	10	8	3	3
Keizerkroon	8	14	....	2	5	3	2	....	1	5	3	....	4	1
Do	8	14	....	2	3	4	4	....	2	....	....	....	....	2
Do	8	14	....	4	3	3	3	....	2	1	....	1	2	....
La Fiancée	8	14	....	2	....	4	7	....	....	....	4	....	....	4
Do	5	35	....	....	....	....	7	13	12	3	....	....	....	....
La Nuit	c 10	14	2	5	3	4	....	....	2	....	6	....	....	....
Do	5	35	....	....	5	3	5	7	7	8	8	....	6	....
La Reine	7	21	....	....	2	5	6	5	....	8	1	4	3	3
Do	5	35	....	....	....	....	....	4	7	2	5	7	9	3
Do	8	14	....	....	....	4	6	4	7	5	4	2	5	8
La Tulipe Noire	8	14	....	9	5	3	....	6	....	5	....	4	....	3
Do	7	21	....	....	5	3	8	5	....	....	2	....	5	....
Madame Krelage	7	21	....	....	7	9	5	....	....	5	9	5	4	....
Maiden's Blush	8	14	....	2	4	5	5	2	6	4	....	3	4	....
Do	7	21	....	....	2	7	7	5	....	2	....	5	....	....
Do	5	35	....	....	....	....	3	25	....	7	14	....	4	12
McKinley	8	14	....	....	3	8	....	3	4	....	3	8	....	3
Do	8	14	....	4	4	3	3	4	2	....	2	4	....	9
Do	7	21	....	....	....	2	9	8	1	1	....	....	4	8
Do	5	35	....	....	....	....	....	5	6	12	9	4	5	....
Do	5	35	....	....	1	....	....	....	3	13	11	6	4	4
Mon Trésor	8	14	....	....	3	4	....	4	....	1	....	3	....	....
Do	8	14	....	4	1	4	....	2	....	2	1	1	1	....
Do	7	21	....	....	1	6	3	5	8	....	....	4	....	....
Do	(d)	50	....	....	....	....	....	....	10	12	12	12	5	....
Painted Lady	10–12	11	....	....	4	7	....	10	....	9	....	4	6	....
Do	8	14	....	....	3	8	3	9	3	....	3	1	9	....
Do	7	21	....	....	....	6	8	8	1	3	....	10	7	6
Do	5	35	....	....	....	....	3	25	....	7	14	....	4	10
Pride of Haarlem	10	11	4	3	3	1	....	3	....	4	5	3	....	....
Do	8	14	2	3	6	3	....	....	....	....	4	7	5	4
Do	7	21	....	1	7	5	3	....	3	....	....	....	....	1
Do	5	35	....	....	5	6	9	7	7	1	....	3	....	3
Prince of Austria	8	14	....	....	7	4	2	....	1	....	5	....	2	4
Do	8	14	....	3	4	2	2	3	4	....	....	....	....	2
Do	7	21	....	....	....	9	5	....	5	....	....	5	....	4
Do	7	21	....	....	....	5	11	3	1	4	....	....	....	3
Proserpine	8	14	6	4	2	....	....	1	4	4	....	2	....	2
Psyche	8	14	5	4	2	3	....	....	5	3	....	8	5	3
Rev. H. Ewbank	8	14	....	....	7	5	2	7	....	....	....	1	3	....
Do	7	21	....	....	7	7	6	3	....	10	9	....	....	2

c These were above 10 centimeters.

d Under 5 centimeters.

TABLE 5.—*Propagation of tulip bulbs by rows in the Puget Sound region in 1920*—Contd.

Name and variety.	Bulbs planted.		Number of bulbs dug of each size (centimeters).											
	Size (centimeters).	Number to row.	14	13	12	11	10	9	8	7	6	5	4	3
Rosalind	8	14	....	....	....	2	8	4	14	9	5	7	6	....
Samuel Lover	8	14	....	....	9	5	....	1	9	8	3	3	....	3
Sieraad van Flora	8	14	....	3	7	4	....	....	....	6	....	....	8	8
Do	7	21	....	....	4	4	7	....	1	5	2	....	....	3
Do	5	35	....	....	1	....	3	16	5	7	3	....	....	4
The Sultan	8	14	....	2	3	5	4	4	....	9	....	6	....	....
Do	7	21	....	....	4	10	6	....	6	10	9	7	....	....
Do	5	35	....	....	....	....	5	24	2	10	6	9	13	3
Do	7	21	....	....	2	3	4	3	9	....	7	....	7	5
Thomas Moore	[b] 8	14	....	2	6	5	6	4	6	4	6	6	7	7
Do	7	21	....	....	1	1	11	7	....	9	....	4	....	5
Do	5	35	....	....	....	1	5	17	8	9	1	5	13	9
Do	7	21	....	....	1	10	....	6	7	9	....	3	3	2
Do	5	35	....	....	....	....	12	3	12	11	10	8	8	10
Do	7	21	....	....	....	3	7	9	8	6	....	5	7	7
Do	[d]	50	....	....	....	....	....	7	10	10	22	....	11	18
White Swan	7	21	....	1	8	7	5	....	4	....	3	12	....	5
Do	8	14	....	2	9	....	2	1	....	6	8	9	7	....
William III	5	35	....	....	....	....	6	15	10	6	....	7	10	8
Do	8	14	....	....	8	6	....	....	9	6	....	8	8	4
Yellow Prince	8	14	....	....	10	3	....	1	....	3	....	2	....	3
Do	5	35	....	....	....	....	4	8	....	8	11	1	....	....

[b] An average in round numbers of 10 readings.

[d] Under 5 centimeters.

PROPAGATION REVEALED BY THE PLANTING RECORD.

Another way of judging of the performance of tulip stocks is by a comparison of planting records from year to year. With this, of course, must be coupled the turn-off. It should be noted that it is at planting time that the bulb grower gets a count of his planting stock. He does it by getting a count of the rows planted, as described elsewhere.

Table 6 presents a résumé of the planting records of the new garden at Bellingham, Wash., for the years 1919 and 1920 for 39 varieties of tulips. It will be seen readily that the computation of a record of yield from a planting of tulips is a complicated affair. It is therefore advisable to present quite a complete record in order that the reader himself may be able to weigh the factors.

In studying Table 6 it is necessary to compare not only the totals of bulbs planted but also the relation of the sizes. To a degree this is expressed in the weights. To arrive at the complete performance of a variety the turn-off in 1920 and the discard given in the footnotes, of course, must also be considered.

In the comparison is given, first, the name of the variety and its class, then five columns headed by figures showing the number of bulbs planted to the row, which are followed by a column for the total of bulbs planted, and finally the weight of the bulbs planted in 1919. The same method of presentation is followed for 1920.

The numbers heading the five columns already mentioned govern quite definitely, except where noted, the size of bulb planted; but the method of sizing needs elucidation here in order to completely understand the reproduction and propagation.

The methods used in sizing were quite uniform. It will be noted that but few elevens were planted in 1919. This means that merchantable stock was not as a rule put back in the ground. In the sizing the conventional nesting sieves were used. Sieves of 8, 7, and 5 centimeters were nested in a hand shaker, as shown in Plate XV, Figure 1. Those bulbs caught by the 8-centimeter sieve were planted 14 to the 3-foot row, those by the 7-centimeter sieve 21 to the row, and those by the 5-centimeter sieve 35 to the row. The smallest size which passed the 5-centimeter openings in the last sieve was planted 50 to the row. In a few cases a 10-centimeter sieve was employed to take out bulbs, which were planted 11 to the row.

TABLE 6.— *Yields of 39 varieties of tulips, as shown by the planting records at Bellingham, Wash., for 1919 and 1920.*

[Symbols designating the varietal class: Br=Branching, Dar=Darwin, DE=Double Early, SE=Single Early, SL=Single Late.]

Name of variety.	Class.	1919							1920						
		Number of bulbs of each size planted.					Total planted.		Number of bulbs of each size planted.					Total planted.	
		11 to row.	14 to row.	21 to row.	35 to row.	50 to row.	Bulbs.	Weight (pounds).	11 to row.	14 to row.	21 to row.	35 to row.	50 to row.	Bulbs.	Weight (pounds).
Admiral Piet Hein [a]	Dar	.....	140	168	105	150	563	8	275	112	63	35	.....	485	22
Allard Pierson [b c]	Dar	1,001	280	294	210	.....	1,785	.....	1,430	686	924	1,575	1,400	6,015	136
Artus [d]	SE	.....	3,696	14,133	12,845	14,450	45,124	582	825	.....	.....	.....	.....	825	40
Bacchus [b]	SE	.....	252	100	105	.....	457	18	187	126	126	105	250	794	22
Baronne de la Tonnaye [e]	Dar	.....	700	609	315	.....	1,624	30	77	392	525	420	950	2,364	28½
Belle Alliance [f]	SE	132	812	231	105	400	1,680	46	374	196	399	350	750	2,069	51
Blanc Bordé Pourpre [g]	DE	.....	4,648	8,484	.....	.....	13,132	265	.....	672	5,250	6,160	8,500	20,582	187
Calliope [b]	Dar	.....	294	483	350	.....	1,127	20	869	252	210	280	450	2,061	53
Cardinal's Hat [h]	SE	.....	19,348	20,496	19,775	.....	59,619	1,120	2,233	.....	.....	.....	.....	2,233	120
Clara Butt [i]	Dar	.....	5,502	8,799	4,865	.....	19,166	450	.....	2,856	6,027	7,595	13,550	30,028	311
Cottage Maid [j]	SE	.....	1,078	567	630	950	3,225	.....	.....	700	735	875	.....	2,310	40
Couleur Cardinal [b]	SE	.....	1,554	945	595	600	3,694	66	1,562	616	441	385	450	3,454	110
Couleur Cramoisi [k]	SE	.....	2,464	2,352	1,575	2,100	8,491	141	.....	2,268	1,722	3,010	.....	7,000	111
Crimson King [l]	SE	.....	1,638	2,163	1,610	1,700	7,111	113	1,650	1,134	1,407	700	.....	4,891	54
Duchess de Parma [m]	SE	.....	1,358	1,029	700	800	3,887	70	1,661	896	483	1,120	.....	4,160	113
Eugene de la Croix [b]	Dar	.....	98	84	70	.....	252	5	132	112	63	70	50	427	12½
Europe [n]	Dar	154	392	1,239	630	.....	2,415	50	1,056	462	336	385	750	2,989	80
Fairy Queen [b]	SL	.....	294	567	350	.....	1,211	20	704	518	735	350	500	2,807	63½
Fulgens [o]	SL	.....	812	1,470	1,190	.....	3,472	75	220	672	1,470	1,470	3,400	7,232	88
Isabella [b]	SL	.....	1,106	609	770	.....	2,485	51	1,628	602	1,008	980	1,650	5,868	133
La Fiancée [b]	Dar	.....	112	105	140	.....	357	6	187	112	42	.....	50	391	15
Marconi [b]	Dar	.....	168	252	350	.....	770	12	572	154	147	105	250	1,228	39½
McKinley [p]	SE	.....	4,046	3,738	3,465	4,300	15,549	215	3,597	2,576	2,142	3,150	5,200	16,665	355
Mons. S. Mottet [b q]	Br	66	84	42	70	100	362	8	77	70	126	175	150	598	11
Painted Lady [r]	Dar	154	140	252	245	250	1,041	19	66	350	378	280	.....	1,074	25
Parisian Yellow [b]	SL	.....	196	84	105	.....	385	9	154	84	63	105	100	506	14
Pierre Loti [b s]	Dar	.....	392	399	315	.....	1,106	22	759	266	231	175	350	1,781	67
Proserpine [b]	SE	.....	[t] 504	63	140	.....	707	.....	440	126	147	70	350	1,133	38
Psyche [b]	Dar	.....	378	189	350	.....	917	37	671	196	399	210	300	1,776	56
Remembrance [u]	Dar	.....	126	651	455	.....	1,232	24	110	392	378	175	400	1,455	30
Rev. H. Ewbank [b]	Dar	.....	154	273	245	.....	672	12	495	182	210	140	250	1,277	35
Sieraad van Flora [b]	Dar	.....	392	252	210	.....	854	21	561	154	147	105	300	1,267	46½
Sir Joseph Hooker [b]	Dar	.....	126	42	35	.....	203	4	132	70	.....	105	100	407	9½
The Sultan [v]	Dar	.....	2,212	5,880	1,015	.....	9,107	167	649	2,198	2,940	.....	.....	5,787	60

Thomas Moore *w*	SE		5,950	5,313	3,465	7,150	21,878	325	1,716	602	504	1,030	1,300	5,172		
Titian *b x*	DE		*y* 322	189	105	100	716	14	187	252	189	105	200	933	23	
Vuurbaak *b z*	DE		*y* 560	189	140		889	38	682	210	189	175	300	1,556	54	
Wedding Veil *b*	Dar		98	210	245		553	10	220	266	84	70	250	890	22	
William III *b*	DE		280	273	735		1,288	26	594	378	294	245	750	2,261	54½	

a Note the relative increase in size, a large increase in weight, but an actual decrease in the number of bulbs, probably due to a large number of the fifties failing to grow and there being little or no reproduction in the small sizes planted.

b All the stock planted.

c Contains one lot of 1,091 bulbs imported in 1919 and planted late.

d A total of 22,800 bulbs were turned off, an endeavor being made to pick out all that would flower. Many small, scarcely merchantable bulbs were therefore included. The nonflowering stock to the extent of 50,400 bulblets, weighing 448 pounds, was discarded. These were nearly all under 8 cm. in circumference.

e A total of 900 bulbs, above 10 cm. in circumference were disposed of, weighing 59 pounds.

f A total of 450 bulbs were marketed, weighing 24 pounds. This record is of one lot only.

g A total of 11,000 bulbs were disposed of, weighing 427 pounds; yield very poor for this variety on account of bad drainage.

h The turn-off was 50,000 bulbs and included all bulbs which would flower. They weighed 1,801 pounds. The discarded small bulbs, mostly 8 cm. and under, weighed 500 pounds and numbered about 50,000 also.

i Disposed of 15,000 bulbs, weighing 736 pounds. Compare Figures 3 and 4, Plate V.

j The bulbs planted in 1919 were dug as soon as flowers had faded and were therefore small and poorly developed. A total of 300 bulbs were marketed, weighing 26 pounds.

k A total of 3,500 bulbs disposed of, all above 10 cm.; all below 5 cm. were discarded.

l A total of 1,350 first-size bulbs were disposed of; all below 5 cm. were discarded.

m All below 5 cm. discarded and not counted or weighed.

n A total of 650 bulbs were marketed, weighing 40 pounds.

o A total of 1,500 bulbs were marketed, weighing 97 pounds.

p A total of 3,000 bulbs were marketed, weighing 179 pounds.

q Lower end of the plat was badly injured by poor drainage.

r A total of 400 mature bulbs were turned off, weighing 21 pounds, and all below 5 cm. were discarded.

s Reproduction always poor in this variety.

t These were larger than those normally planted as fourteens, being bulbs dug as soon as the flowers faded, and therefore not well developed for 1919 planting.

u A total of 400 bulbs were turned off, weighing 26 pounds.

v A total of 6,120 bulbs were marketed, weighing 347 pounds, and 60 pounds of small bulbs below 7 cm. were discarded.

w A total of 15,600 bulbs were marketed, weighing 517 pounds. These included all the bulbs which would flower out of a further discard of 14,000 bulblets under 7 cm., weighing 112 pounds.

x This is always a small reproducer, but very small bulbs blossom. In other words, the splits are comparatively large.

y Although planted as fourteens these bulbs were of larger size than those ordinarily set 14 to the row.

z This is probably subnormal, because the bulbs planted in 1919 were dug shortly after the flowers had faded.

RESULTS IN TERMS OF ACRE YIELDS OF MATURE BULBS.

It should be noted that the experimental acre at Bellingham, Wash., is shorter than it would be in commercial plantings on the right kind of soil. For this reason the results are conservative. The lands are approximately 400 feet long. The actual planted area on the acre consists of two plats varying from 42 to 45 feet wide and 380 feet long, the remainder of the acre being occupied by ditches, roadways, fence rows 12 feet inside of the line, etc. There are therefore on an acre 190 beds or 95 beds in each plat, each bed with its attendant path being 4 feet wide and extending across the plat.

Table 7 gives an acre-performance turn-off for two years. Records of bulbs turned off relate to merchantable stocks except where the contrary is noted. In all cases the turn-off was picked out of the stock at cleaning time by hand, and no sizing was done on it.

TABLE 7.—*Plantings and yields of merchantable tulips on 1 acre at Bellingham, Wash., in 1919 and 1920.*

Name of variety.	Bulbs of all sizes planted in the previous year.	Bulbs marketed.	Name of variety.	Bulbs of all sizes planted in the previous year.	Bulbs marketed.
Season of 1919:			Season of 1919—Continued.		
Artus	89,198	23,300	White Swan	2,429	.....
Bacchus	631	.....	Yellow Prince (Pl. XVI, Fig. 1)	5,188	2,200
Bakhuis	64	.....			
Bizard Verdikt	4,174	800			
Brutus	67	.....	Total	339,983	86,994
Cardinal's Hat	78,694	22,000	Season of 1920:		
Chrysolora	488	.....	Acuminata	84	.....
Cottage Maid	5,156	1,800	Admiral Piet Hein	563	.....
Couleur Cardinal	7,593	3,694	Advance	147	.....
Couleur Cramoisi	11,538	2,100	Alitz	1,176	600
Crimson King	10,780	1,300	Allard Pierson	784	.....
Duchess de Parma	9,657	2,000	Andre Doria	1,134	.....
Duchess of Austria	229	.....	Anton Roozen	1,061	.....
Duc van Thol	300	.....	Apollo	63	.....
Dusart	209	.....	Arentine	1,310	450
Joost van den Vondel	438	.....	Artus [a]	45,124	22,800
Keizerkroon	9,726	2,400	Auber	756	.....
King of the Yellows	1,359	.....	Aurora	196	.....
Lac van Rhijn	3,983	400	Aximensis	1,099	500
La Reine	5,654	1,700	Bacchus	457	.....
L'Immaculée	4,254	400	Baronne de la Tonnaye	1,624	900
McKinley	19,348	6,400	Belle Alliance	1,680	450
Mon Trésor	16,878	2,500	Billietiana	994	500
Ophir d'Or	193	.....	Bizard Verdikt	3,663	1,450
Pottebakker	1,080	.....	Boule de Neige	504	300
Prince of Austria	9,002	4,200	Bridesmaid [b]	2,284	1,600
Princess Marianne	8,959	2,800	Brutus	49	.....
Proserpine	124	.....	Caledonia	1,071	500
Rosamundi Huykman	955	.....	Calliope	1,127	.....
Rose Aplatie	76	.....	Cardinal's Hat [a]	59,619	50,000
Rose Gris de Lin	2,132	400	Carinata Rubra	973	400
Thomas Moore (Pl. XVI, Fig. 3)	27,467	6,000	Carl Becker	1,029	500
Titian	758	.....	Chrysolora	336	.....
Van Berghem	158	.....	Clara Butt [b]	19,166	15,000
Van der Neer	37	.....	Columbus	448	.....
Van Gooyen	130	.....	Cottage Maid	3,225	1,100
Vermilion Brilliant	877	.....	Couleur Cardinal	3,694	.....
			Couleur Cramoisi	8,491	3,500

[a] In Artus, Cardinal's Hat, and Thomas Moore, an effort was made to turn off every bulb that would flower. The yield is, therefore, abnormally high. To arrive at the merchantable stocks in these varieties about 60 per cent must be deducted.

[b] In Clara Butt, The Sultan, and Bridesmaid, small flowering bulbs were also included. A deduction here of 25 per cent will leave about the proper number of merchantable bulbs.

TABLE 7.—*Plantings and yields of merchantable tulips on 1 acre at Bellingham, Wash., in 1919 and 1920*—Continued.

Name of variety.	Bulbs of all sizes planted in the previous year.	Bulbs marketed.
Season of 1920—Continued.		
Couronne d'Or	224	.....
Crimson King	7,111	1,350
Didieri	322	.....
Didieri lutescens	84	.....
Dora	336	.....
Duchesse de Parma	3,887	.....
Duchess of Austria	225	.....
Duc van Thol	288	.....
Dusart	175	.....
Edmée	357	.....
Edouard Andre	1,050	.....
Elegans	203	.....
Elegans rosea	434	400
Elegans variegata	49	.....
El Toreador	14	.....
Eugene de la Croix	252	.....
Europe	2,415	650
Fairy Queen	1,211	.....
Fanny	812	.....
Farncombe Sanders	2,856	1,050
Faust	1,414	750
Fra Angelico	879	600
Fragrans	42	.....
Fulgens	3,472	1,500
Galatea	1,029	350
General Köhler	747	.....
Gesneriana aurantiaca	805	900
Gesneriana spathulata major	728	.....
Gizeldi	991	.....
Gold Cup	1,708	800
Golden Crown	2,415	1,200
Golden Eagle	609	.....
Golden King	763	300
Golden Queen	1,958	750
Goldflake	1,141	900
Gretchen	6,372	1,300
Heroine	623	.....
Hofdyk	413	.....
Isabella	2,485	.....
Jassi Prince William	476	.....
Joost van den Vondel	240	.....
Kaufmanniana	35	.....
Keizerkroon [c]	6,063	4,100
La Candeur	2,198	.....
La Citadelle	534	.....
Lac van Haarlem	8	.....
Lac van Rhijn	3,457	1,700
La Fiancée	357	.....
La Merveille	518	300
La Nuit	112	.....
La Reine	4,119	1,800
La Tulipe Noire	434	250
Leonardo da Vinci	560	.....
L'Immaculée	2,364	600
Lucretia	437	.....
Maculata major	280	.....
Madame Krelage	553	.....
Maiden's Blush	1,155	300
Marconi	770	.....
Mary Stuart	336	.....
McKinley	15,549	3,000
Mina	1,358	.....
Miss Blugbro	399	.....
Mixture	.....	1,800
Mon Trésor	8,877	1,900
Season of 1920—Continued.		
Murillo	2,031	700
Nauticus	833	450
Night	679	350
Nora Ware	1,940	700
O'Brien	287	.....
Ophir d'Or	162	.....
Osmar	70	.....
Osmodee	966	350
Painted Lady	1,041	400
Parisian Yellow	385	.....
Patis	560	.....
Pensée Amère	854	400
Perfecta	212	.....
Philip de Comines	767	.....
Picotee	2,023	875
Pierre Loti	1,106	.....
Planifolia	294	.....
Pottebakker	211	.....
Pride of Haarlem	1,317	.....
Prince of Austria	5,560	.....
Princess Marianne	4,310	2,400
Prince William I	490	.....
Professor Trelease	1,099	450
Proserpine	707	.....
Provost des Exilles	623	350
Psyche	917	.....
Ragout	119	.....
Reine Wilhelmina	196	.....
Remembrance	1,232	400
Retroflexa	924	300
Rev. H. Ewbank	672	.....
Rex Rubrorum	5	.....
Roi de Prusse	70	.....
Rosalind	1,904	800
Rosamundi Huykman	679	.....
Rose Aplatie	77	.....
Rose Blanche	225	.....
Rose Gris de Lin	660	.....
Rubra maxima	609	.....
Salvator Rosa	529	.....
Samuel Lover	1,218	450
Sanspareil	133	.....
Sieraad van Flora	854	.....
Sir Joseph Hooker	203	.....
Talma	315	.....
The Sultan [b]	9,107	6,120
Thomas Moore [a]	21,878	15,600
Titian	716	.....
Tournesol	805	.....
Valentin	203	.....
Van Berghem	98	.....
Van der Neer	14	.....
Van Gooyen	99	.....
Vermilion Brilliant	1,156	.....
Viridiflora	70	.....
Viridiflora praecox	259	.....
Von Jehring	532	.....
Vuurbaak	1,100	.....
Wedding Veil	553	.....
White Swan (Pl. II, Fig. 1.)	5,350	1,500
William III	1,288	.....
Wouwerman [c]	2,099	1,900
Yellow Prince	2,928	.....
York and Lancaster	588	250
Total	354,930	163,845

[a] In Artus, Cardinal's Hat, and Thomas Moore, an effort was made to turn off every bulb that would flower. The yield is, therefore, abnormally high. To arrive at the merchantable stocks in these varieties about 60 per cent must be deducted.

[b] In Clara Butt, The Sultan, and Bridesmaid, small flowering bulbs were also included. A deduction here of 25 per cent will leave about the proper number of merchantable bulbs.

[c] These were bedding bulbs, dug and heeled in to ripen as soon as the flowers had faded in 1919. The reproduction was small, but the original bulbs recovered perfectly in one year, although planted 14 to the row.

The turn-off of bulbs from the acre in 1919 will be seen to total 86,994. In 1920 the turn-off totaled 163,845 bulbs, but for certain reasons it was desirable in that year to get rid of as many bulbs of some varieties as possible. Consequently, all bulbs of these varieties that would flower were disposed of. Many of these bulbs were smaller than should have been sold for anything but planting stock. Of this latter class there were, as nearly as can be estimated, 58,720. Deducting this from the total, there is a net merchantable turn-off of 105,125 bulbs from the acre in 1920.

The yield in 1920 is further slightly augmented by the fact that there were planted on the acre about 10,000 bulbs of all sizes which had been used for bedding on the grounds of the Department of Agriculture at Washington, D. C., in the spring of 1919. These, while not normal for first-quality stock, nevertheless probably gave a greater proportion of merchantable bulbs in 1920 than the average run of the Bureau of Plant Industry planting stock. The reproduction in these stocks, however, was much below normal. These relations are well brought out in the narrow ratio between the number of bulbs planted and the number turned off as merchantable in some varieties in Table 7. In Wouwerman only 2,099 were planted and 1,900 were turned off. This may necessitate reducing the total turn-off to 100,000.

Table 7 contains lists of all the varieties grown on the tested acre of ground devoted to tulips each year. The blanks opposite the varieties in the "Marketed" column indicate in practically every case that all the stock was planted back in the autumn of 1920. The 1919 list, as will be seen, is comparatively short in number of varieties and made up very largely of single earlies, which were the only stocks grown on the new place that year.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
25 CENTS PER COPY

▽